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J. F. KELLY, Editor

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Association of Iron & Steel Electrical Engineers

Combustion Engineering Division

MID WINTER CONFERENCE

WEDNESDAY, JANUARY 23rd, 1929

LIST OA

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"The Isley Open Hearth Furnaces."

"The Use of Heat Resisting Alloy Steel in the Steel Plant."

"Furnace Bindings."

"Fuel Utilization Practices in Europe."

"Employees Training for Combustion Work and Co-operation With Other Departments."

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EDITORIAL

To the Executives,
Iron & Steel Industry,
United States & Canada,

Gentlemen:

The Combustion Division of the Association of Iron & Steel Electrical Engineers was inaugurated in 1921 to render to the Iron and Steel Industry a Fuel Service and up to the present, this Division has contributed approximately 100 papers dealing with features of Combustion Engineering that are of vital interest and importance to the Iron and Steel Industries' Fuel Problems.

To further contribute to the service that the Combustion Division of this Association has rendered the Industry, we are contemplating the publication of a reference volume dealing with all the major Fuel Problems encountered in the making and treating of Steel. We realize the magnitude of the work that we are about to undertake and know that the value of this volume will depend upon the information we will collect from the Industry.

Our plan is to have each of the various phases of Steel Plant fuel practice handled by one of the leading authorities on each particular subject, backed by the data that we will collect from the Industry at large.

Your co-operation is solicited and we are asking you (as we may request from time to time) to permit us to obtain from your plants such information as to the kind and quality of fuels now in use, also the methods and apparatus involved in their utilization. Fuel is a most important and large item in your costs and we assure you we have in mind no other thought than to aid you to reduce this cost. In return, we ask you to help us by contributing the data on your fuel practices. It being understood, of course, that we will not divulge in any way the source of our information that will reflect upon your plant operation.

In closing, let us emphasize the fact that there is not at present such a reference work available to which your Engineers may refer, giving under one cover the above described valuable information on the Fuel Problems of the Steel Industry. This piece of work that we are undertaking is large and will take at least one year to complete it, however, when finished, it will be of inestimable value and available to each of the Steel Companies contributing data to this reference volume.

Thanking you for your kind interest and feeling sure that you will give us your hearty support without hesitation in view of the importance of this subject, we are

Yours very cordially,

C. S. PROUDFOOT,
President,
Association of Iron & Steel Electrical Engineers.

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The Rod Mill Electrification at the South Works of the American Steel & Wire Company, Worcester, Mass.

ROGER H. BRYANT*

THE last eighteen months have seen the almost complete replacement and electrification of the hot rolling mills at the South Works of the American Steel & Wire Company in Worcester, Massachusetts. The only steam-driven unit remaining in the main group of mills is the 35-inch reversing blooming mill.

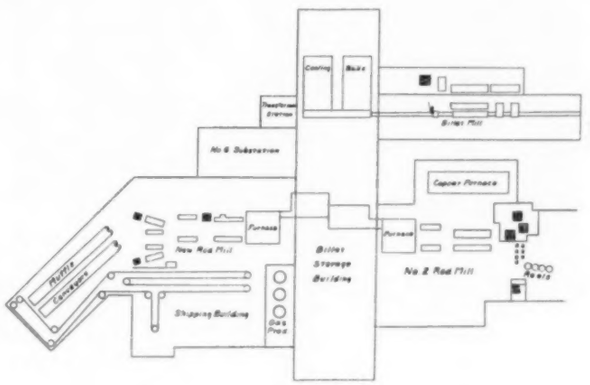

FIG. 1.

The former practice was to roll the ingots as received from the open Hearth furnace, down to 4x4 section in the blooming mill and cut them into billets 54 inches long weighing about 220 pounds each. These billets were then reheated, rolled in a billet mill to about 1¼ inch rounds and then fed directly into one of three rod mills. The demand for heavier bundles of rods and for improved quality, together with the high cost of rolling on old equipment, dictated a change to new equipment and a different practice. Accordingly, an 18-inch continuous billet mill has been installed directly in back of the blooming mill; a new high speed rod mill has been built on the site of the old No. 3 rod mill; No. 2 rod mill has been entirely rebuilt and rearranged, with some additional stands; No. 1 rod mill has been dismantled and a new electric substation, No. 6, to take care of increased power usage and to provide direct current, has been built adjacent to the mills. The new practice is to roll the ingot to a 5x5 section in the blooming mill, crop off the ends, and pass it directly into the continuous billet mill without reheating, where it is reduced to 2x2 and cut into 30-foot lengths by a flying shear. These 2x2 billets are then reheated and rolled into rods. Figure 1 is a plan of the various mills showing how they are located with respect to each other and how easily the billets are transported from the cooling beds to the furnace chargers.

All electric power for the operation of these mills is purchased as 3 phase, 60 cycle power at 13,200 volts from the New England Power Company and is transmitted through their Millbury substation, which is the load dispatching center of their system. A total of 10 high tension lines from the Hydroelectric stations in the western part of the state and the steam stations at Boston and Providence converge at Millbury, assuring a constant supply of power as free from interruptions as possible. Power is transmitted about 5 miles from this substation at 13,200 volts over three separate pole lines providing four circuits to No. 5 substation at the edge of the American Steel & Wire

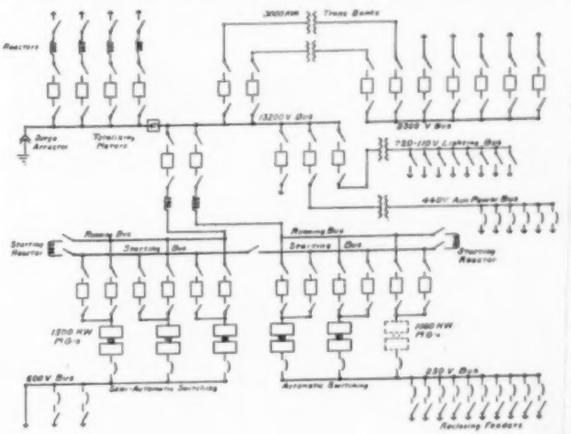

FIG. 2.

Company's yard. At No. 5 substation there is installed a 7500 k.v.a. synchronous condenser with automatic control to regulate voltage. From the bus at this substation, three 350,000 circular mil 3-conductor paper insulated lead covered sector cables carry power approximately 4,000 feet through an underground duct line to No. 6 substation at the rolling mills. Other cable lines also connect to the bus at No. 5 substation to feed the remainder of South Works through the old distribution system.

The building housing No. 6 substation is of brick and steel construction approximately 100 feet long by 50 feet wide and with a basement extending about 30 feet out under the yard. The cables terminate on the wall of the basement extension and connect through disconnecting switches to air core reactors for limiting the short circuit current to within the capacity of

*Worcester District Electrical Engineer, American Steel & Wire Company.

the circuit breakers. All the 13,200 volt oil circuit breakers are type FH-203, built by the General Electric Company and mounted in steel trucks. Through lack of head room, all 13,200 volt connections between circuit breakers, reactors, etc., are made by short pieces of paper insulated lead covered cables which can be carried in between floor beams and other places where there would not be room for open work. Figure 2 is a schematic diagram of the main connections in the substation. Provision is made for four incoming lines which are paralleled on to the 13,200 volt bus. A surge arrestor of the oxide film type takes care of high voltages that may be produced on this bus by switching or other disturbances. All power delivered to the substation is metered on the bus to check the measurement of the New England Power Company made at No. 5 substation. From the bus, feeder circuits go to the following:

600-volt motor generators,
250-volt motor generators,
No. 1 transformer bank,
No. 2 transformer bank,
450 k.v.a., 440-volt transformer for auxiliary power,
200 k.v.a. lighting transformer,
Spare feeder.

The 13,200 volt and 2300 volt switches are controlled from a steel panel board mounted on the operating floor and shown in Figure 3. Meters, relays and control switches are mounted on this board for the control of four incoming lines, a totalizing panel with recording voltmeter, power factor meter and Westinghouse type "RA" watthour and demand meter, high and low tension sides of two transformer tanks, high tension side of auxiliary power and light transformers, spare 13,200 volt feeder, and five 2300 volt feeders. Adjacent to the steel panels are asbestos board panels with air circuit breakers for six 440 volt, 3 phase circuits and eight 3-wire 220-110 volt, single phase lighting circuits. The panels at the end of the board control the strorage battery charging equipment and control power circuits to the different switchboards.

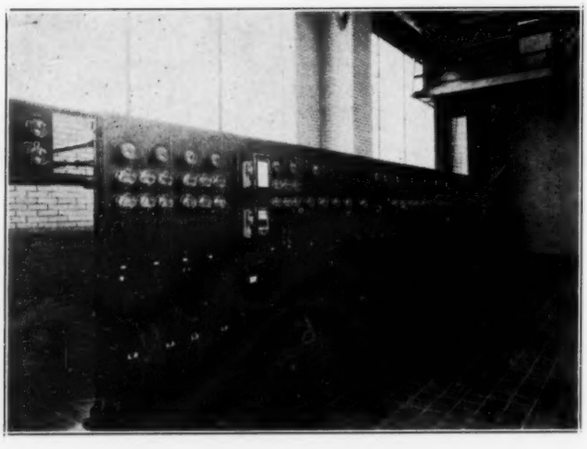

FIG. 3.

Provision has been made for six motor-generator sets having a total nominal rating of 7500 kilowatts, but only five of them have been installed. Figure 4 is a general view of the operating floor of the substation showing the motor-generators. In the foreground are three two-unit, three-bearing machines, each having a 1500 kilowatt, 600 volt compound wound generator driven at 600 r.p.m. by a 3 phase, 60 cycle, 13,200 volt, 80% leading power factor synchronous motor. Each synchronous motor field is excited by a generator mounted on the end of the shaft, while the generator field is separately excited by a motor driven exciter which also supplies field for the three motors driving the new rod mill. The control of these three motor-generators is through a semi-automatic switchboard. The substation operator starts and stops the motor-generators as needed and regulates the voltage and load division. Starting and paralleling on to the 600 volt bus are entirely automatic after the operator pulls the starting switch. A full complement of relays provides protection against overload, single phase operation, hot bearings, reverse current, etc. These three motor-generators supply power to the main roll motors of both rod mills, the total connected load being 8200 horse power. All energy delivered to the motor-generators is measured as well as the output so that accurate accounting is possible. Each feeder is also equipped with watthour meter. All direct current

FIG. 4.

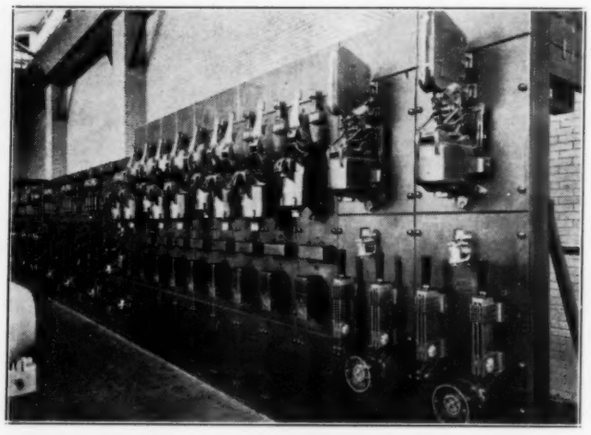

FIG. 5.

watthour meters used in the substation are of the shunt type.

Power for operating the various auxiliary drives is provided by two motor-generators, each consisting of a 1000 kilowatt, 250 volt shunt wound generator driven at 720 r.p.m. by a 3 phase, 60 cycle, 13,200 volt, 80% leading power factor synchronous motor. Separate exciters on the ends of the shafts are supplied for the synchronous motors. The control of these motor-generators is by a full automatic switchboard, shown in Figure 6, and designed for three machines. The first machine is started by the operator and the second ma-

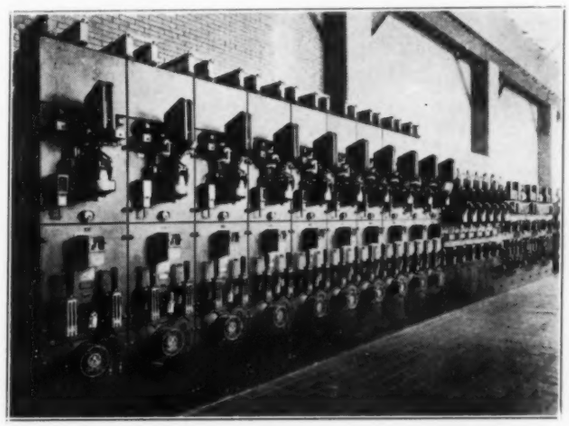

FIG. 6.

chine is controlled by load responsive relays. Either machine may be made the leading one. Automatic control of voltage is provided to maintain constant voltage up to 150% load and constant current thereafter. All the usual protective devices are also included. Distribution of the 250 volt power is through

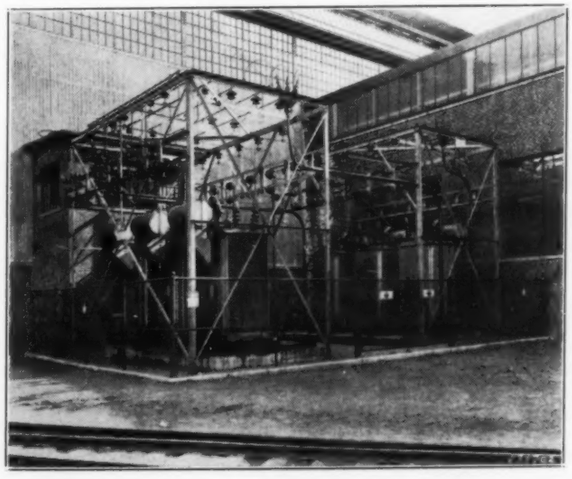

FIG. 7.

ten feeder panels of the automatic reclosing type, each rated at 2000 amperes. The electric energy delivered to the motor-generators is measured as well as the output of each generator and each feeder, so that accurate distribution of charges can be made.

There are two banks of transformers located just outside the substation building. Each bank consists of three 1000 k.v.a. single phase, oil insulated, self-cooled transformers, delta connected, with a ratio of 13,200 to 2300 volts and with four full capacity taps on the high tension winding. Disconnecting switches are provided so that each transformer can be separately disconnected to permit operation in open delta if necessary. All transformers are mounted on trucks and set on rails for easy removal. Both high and low tension connections between the transformers and the switches in the substation basement are made by cable in iron conduit. A general view of the installation is given in Figure 7. The 2300 volt switches are located in the substation basement and are of the truck type with FKR-32 breakers.

The motor-generator starting and running switches are also located in the basement and are of the truck type with a double overhead bus arrangement. The

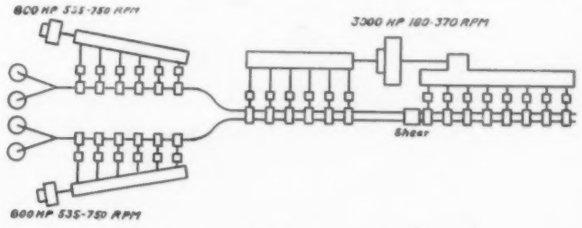

FIG. 8.

running bus is energized directly from the 13,200 volt bus through an oil switch and current limiting reactors similar to the incoming line reactors. The starting bus is in turn energized from the running bus through an iron core reactor designed to provide the right current for starting the synchronous motors. With this method of starting, the motor-generators come up to speed in less than ten seconds and draw about 7500 k.v.a. One starting reactor is provided for each group of motor-generators and disconnecting switches are provided to interconnect the starting buses in case either reactor requires repairs.

FIG. 9.

The motor-generators are mounted on reinforced concrete foundations extending to bed rock. A 15-ton crane serves the operating floor and reaches the basement through a removable section of the floor. A storage battery of 60 cells of sealed glass jar type

provides control power for all equipment in the substation and also for the main motor controls in the billet and rod mills. The field rheostats for both motors and generators are motor operated and are mounted on the basement floor directly below their respective machines. Cooling air is taken in through filters and blown into the basement of the substation, from where it either passes up around the motor-generators or goes through tunnels to the motors driving the new rod mill. The interior walls of the substation are finished with a cream colored brick and the floor is covered with red tile. The auxiliary power and light transformers are in the basement.

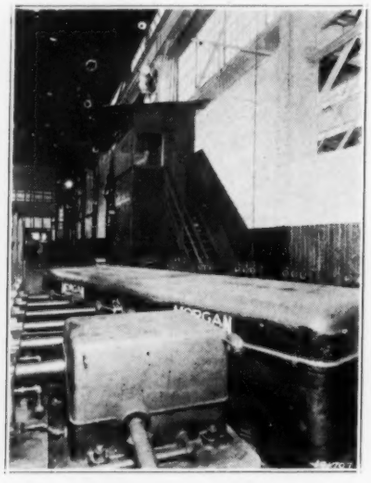

FIG. 10.

The billet mill is driven by a 2500 horse power 50° C. maximum rated wound rotor induction motor. Full load speed is 296 r.p.m. at 2300 volts, 3 phase, 60 cycles. One bearing is provided with thrust collar to take momentary thrust. The motor drives through a breaking spindle and speed reducing gear. Control is full magnetic by a master switch in the operator's pulpit. Oil circuit breakers are used for forward and reverse connection of the primary winding. Contactors with grid resistance are used for the secondary control.

Auxiliary motors on the billet mill include both the mill and industrial types. Roll tables are provided from the blooming mill shear to the billet mill and between the first three stands of the mill. The roll tables at the finishing end of the mill are driven from the main drive. Two cooling beds are provided with a disappearing stop between them. The assembling rolls are driven by a separate motor to take the billets faster than the mill finishes them. The straight edges and go-devils are driven by mill type motors through speed reducing gears and are operated through wire rope drives. The trigger on the flying shear is also traversed by a small crane type motor. All electric controllers are of magnetic type with current limit acceleration and pancake type master switches with plug-in type receptacles for quick change are used.

The new wire rod mill is one of the fastest and best of its kind in the world. It is a double line mill with separate finishing trains as shown in the schematic layout, Figure 8. The roughing and intermediate trains are both driven from the same motor, which is rated at 3000 horse power at 50° C. rise and has a speed range of 180 to 370 r.p.m. by field control. Each finishing train is driven by an 800 h.p., 50° C. rise motor with a speed range of 535 to 750 r.p.m. All three motors operate at 600 volts and are separately excited at 250 volts. Commutating pole and pole face windings are provided and compounding is obtained by use of series exciters so that it can be easily and accurately controlled. Very close speed regulation is obtained at any speed by this method. The motors are started in the usual way by series resistance, affording independent control. Figure 9 is a general view

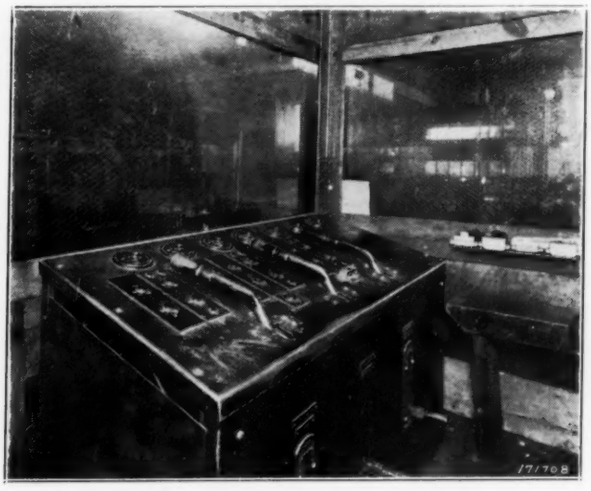

FIG. 11.

of the starting panels which are assembled as one continuous switchboard in the basement of the substation directly below the 600 volt switchboard. The panels are of asbestos board on a channel frame. The resistors are of the grid type and are located above and at the end of the starters. The series exciter is also placed adjacent to the panels and between them and the tunnels leading to the motors. The main leads to the 3000 h.p. motor are made by bus and those to the 800 h.p. motors by cable. The operator of this mill is located above and at the side opposite the point where the two lines diverge to enter the finishing trains. From his pulpit, which is shown in Figure 10, he has a view of the whole mill from the operating side and can see all that goes on. In front of him he has the control desk shown in Figure 11, which is of all steel construction, and for each motor has an ammeter calibrated in horse power, a voltmeter calibrated in r.p.m. operated from a magneto geared to the motor, push buttons for starting, stopping, dynamic braking, inching, and for operating the main motor driven rheostats. Accurate and instant control over a certain range of speed is required, particularly for the motors driving the finishing trains. To this end all motors are provided with vernier rheostats which cover about 15% of the total speed range and which are operated through chains by handles on the bench. Field switches are also provided of double throw type intended for reversing the motors if necessary. Besides starting and stopping the motors as required, the operator's duty is to watch the loops between the intermediate and finishing trains and keep them within bounds by regulating the speed of the motors. All

the motors are in separate houses built of regular sectional steel partition. Figure 12 shows the 3000 h.p. motor, while Figure 13 shows one of the 800 h.p. motors and Figure 14 is an exterior view of one of the houses for an 800 h.p. motor and also shows the gear box of one finishing train.

There are two groups of auxiliary drives connected with this mill. Around the reheating furnace there are five motors for handling the billets and providing draft, and at the finishing end of the mill there are five motors for handling the rod bundles through muffle conveyors where they are cooled and on to a hook carrier where they are cooled enough to be handled. In each case, magnetic control is used and the controllers are grouped in steel partition enclosures where they are protected from dirt and tampering. Figure 15 shows a view inside one of these houses. Push button master switches are provided for those motors which run continuously, while pancake master switches are provided for the others. The continuously running motors are of the industrial type, most of them being either 25 or 35 horse power at 40° with a speed range of 400 to 1200 r.p.m. The mill type motors have special compound windings to limit the no load speed to 150% of the full load speed. Solenoid brakes are used in some cases and in others the motors are plugged.

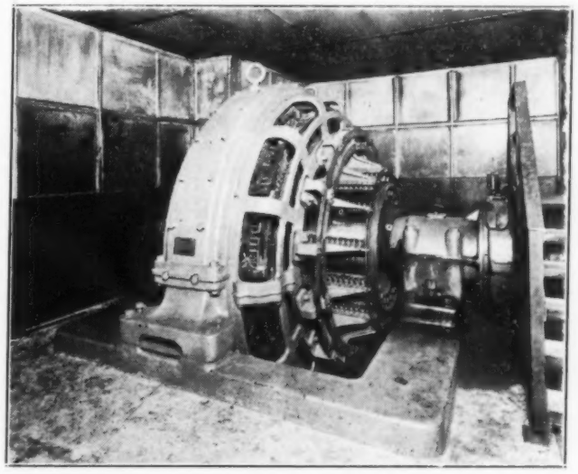

FIG. 12.

The No. 2 rod mill is a merchant mill inteded to roll rounds or shapes up to about 1¼ inches and flats up to 2¼ inches wide. It also rolls round copper rods and a small quantity of figure 8 trolley wire. The finishing mill is of the Belgian type with the rather unusual arrangement of two stands in tandem. The roughing and intermediate stands are driven by a 2000 h.p., 600 volt, 40° C. rise adjustable speed motor with a speed range by field control of 230 to 460 r.p.m. Each of the finishing lines is driven by an 800 h.p., 600 volt, 40° C. rise adjustable speed motor having the wide speed range of 140 to 510 r.p.m. by field control. In addition there is a 450 h. p. motor, previously installed, which is arranged to drive the last finishing stand independently of the rest of the mill. This motor has a speed range of 400 to 650 r.p.m. and is used only when rolling thin flats so that the loop may be kept as short as possible to prevent too rapid cooling of the metal. The control of the three new motors is similar to that in the new rod mill except that the apparatus on the boards has been rearranged to keep the smaller relays farther from the floor. The parts are duplicates. A view of the panels is shown in Figure 16. The three motors and the control panels are located in the same room, a general view of which is given in Figure 17. There is a basement to this motor room and all connections are made by bus or cable in iron conduit. The motors are provided with the same type of winding as those in the other mill and the series exciters are also used. A separate motor driven exciter for the shunt fields is provided and on its starting panel a double throw switch is located for excitation from the regular shop circuit in case the exciter fails. The operator of this mill is located on the opposite side directly in line with the finishing stands. As this mill is in an old building, there is little head room, so that the pulpit is only two feet above the mill floor. When facing the mill, a steel control desk is at the left end of the pulpit, another at the right, and a group of master switches along the front. The desk at the left is for the control of the three new motors and has speed indicating voltmeters operated from magnetos geared to the motors, ammeters calibrated in horse power, field reversing switches, and drum type master switches instead of push buttons for starting, stopping, inching and dynamic braking and controlling speed. The drum type master switches are much superior to the push buttons and are easier to operate. Master switches are also provided to control the exciter and voltmeters show line and exciter potentials. No vernier rheostats are provided except on the 2000 h.p. motor and this only for close adjustment of speed. It is a motor operated rheostat similar to the main field rheostats. All field rheostats are located in the basement of the motor room and are equipped with auxiliary face plates tapped to the main resistance that automatically apply full field whenever the motor is started and then cut down the field current until the auxiliary arm passes the contact point to which the main arm is connected, when the main arm assumes control of the field current and the motor reaches the same speed at which it was operating before it

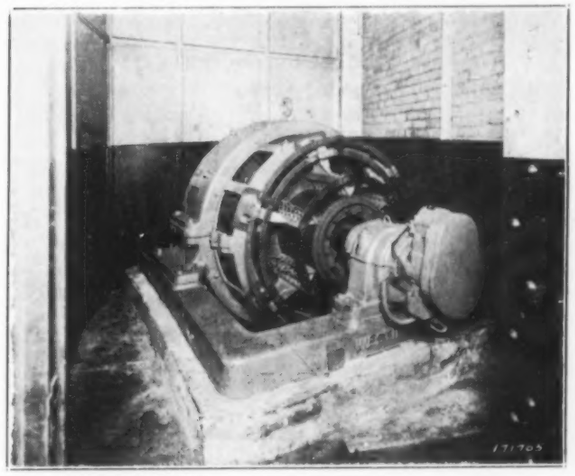

FIG. 13.

was stopped. This speed control arrangement greatly reduces the work of the operator when one or more motors have to be stopped on account of a cobble and assures the reattainment of the correct speed automatically and quickly.

The arrangement of two stands in tandem in the finishing mill with a distance between centers of six feet and with the two stands driven by separate motors,

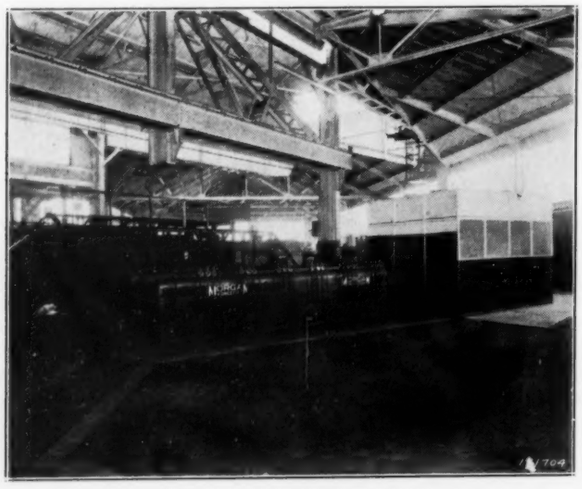

FIG. 14.

made it necessary to have close speed regulation of these motors. To assure maintenance of the speed ratio, it was considered necessary to install some automatic device and this took the form of a synchronous speed regulator which is mounted on a panel which forms an extension of the control panels. It consists essentially of two 3 phase synchronous motors driven by alternating current generators geared to the motors whose speed is to be regulated. The synchronous motors each drive one-half of a differential in opposite

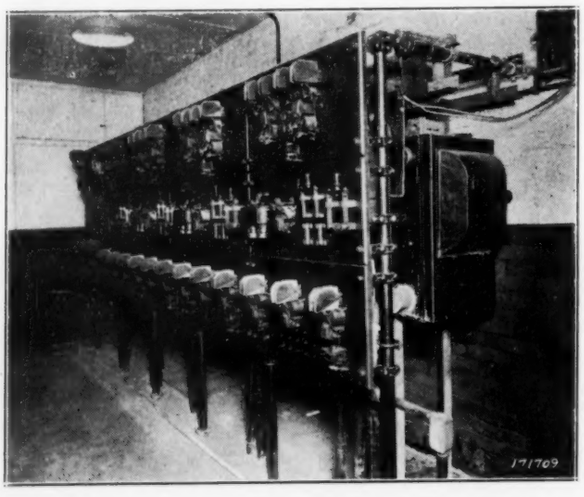

FIG. 15.

directions so that if the speed is the same, the shell of the differential will not rotate. When the speed differs, the shell of the differential will rotate one way or the other, depending on which motor is running faster. This motion is communicated to a movable contact forming part of a vibrating voltage regulator and through it controls the field of one of the motors, causing it to keep in "synchronism" with the other. In order that the speed ratio between the main motors may be altered, one generator is geared to its motor, while the other is driven through a Reeves pulley, the ratio of which can be changed by a small motor controlled from the pulpit. This synchronous type regulator will maintain accurately the speed ratio for which it is adjusted, but in practice it has not been found necessary to use it as a certain amount of pull between stands is practically necessary.

An unusual feature of this mill is the method of driving the four reels, which are of the pouring type built by the Morgan Construction Company. These reels are close to the finishing stand and, therefore, have to run at a speed corresponding to the finishing speed of the mill. Mechanical drive from the last stand was not desirable, so it was done electrically.

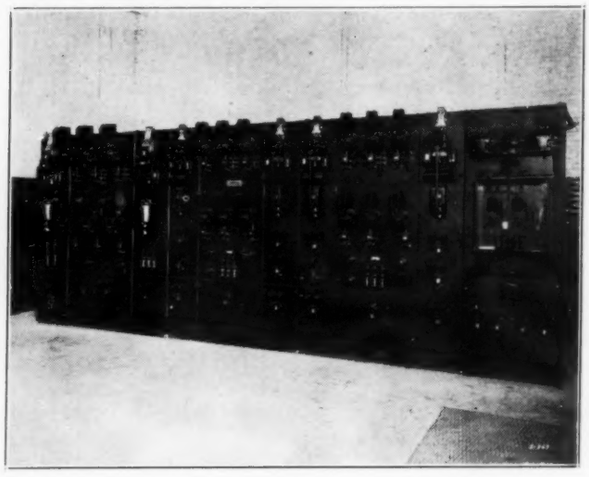

FIG. 16.

A direct current generator rated at 50 kilowatts is driven by silent chain from the last stand. Normal speed of this generator is 900 r.p.m. and it will generate 250 volts at this speed. The ratio of the chain drive is such that this condition will be obtained when the mill is running at maximum speed of 650 r.p.m. Each reel is rotated by a 35 h. p., 250 volt, 1200 r.p.m., separately excited motor, and the gear ratio is such that the reel runs at the right speed to correspond to the maximum delivery speed of the mill. The generator and motor fields are in parallel and excited from the shop circuit at constant potential. Therefore, as the speed of the mill changes, the voltage of the generator changes and consequently, the speed of the reels. This system covers the whole speed range of 140 to 650 r.p.m. finishing speed without trouble. Separate field rheostats in each motor field circuit permit a small range of adjustment. Operating handles for these, as well as speed indicating voltmeters for each reel and generator and ammeter and voltmeter on the generator output, are mounted on a small bench board at the right end of the pulpit. The reel motors are started and stopped by regular magnetic starters interlocked with those for controlling the stripper plate motors, so that the reels can be rotated only when the stripper plates are in the lowest position, and the

stripper plates can not be raised when the reels are rotating. All reel motions are controlled from eight pancake type master switches arranged along the front of the pulpit.

The auxiliary motors connected with this mill comprise a group of five to handle billets into and out of the furnace, these motors being duplicates of those on the other furnace. Their control equipment is also the same and is housed in the same way.

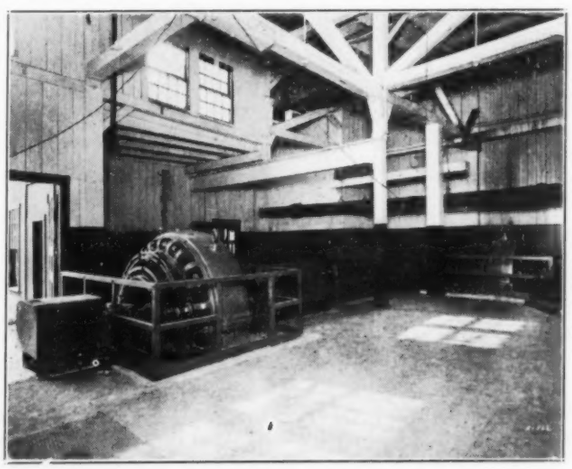

FIG. 17.

Special arrangements had to be made to roll copper on this mill. The copper billets used are 54 inches long and about 4x4, weighing some 260 pounds each. These are heated in an oil fired furnace on the back side of the mill and conveyed to the first stand. On account of the large reduction and number of stands in the intermediate mill, it has been necessary to run the 2000 h. p. motor driving this mill at 150 r.p.m. To get such a low speed, double throw switches were installed in the basement of the motor room so that either 600 or 250 volts can be applied to the armature of this motor, and at 250 volts it has a speed range of about 90 to 180 r.p.m. Naturally, the load that it can carry is greatly reduced on account of poorer ventilation at lower speed, so that it has been necessary to assist the natural draft. Otherwise, no troubles have been encountered, although the motor was not originally designed for such operation.

The billet reheating furnaces are fired by producer gas, two producers being installed for this purpose. These are rotated by 4 h. p. variable speed shunt wound motors. Coal for these producers is dumped from cars into a hopper, from which it goes to a crusher and is then lifted into overhead bunkers by a bucket elevator. The same buckets also carry the

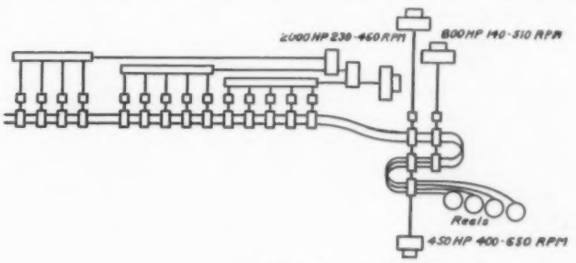

FIG. 18.

ashes into an overhead hopper, from which they are delivered into cars by gravity. The coal and ash handling equipment is operated by standard squirrel cage induction motors.

The artificial lighting throughout the new mill buildings has received special attention. The lighting units were manufactured by the Holophane Company and most of them are of the high bay type hung on messenger cables and arranged for easy removal for cleaning. Intensities ranging from 3-foot candles in storage areas to 13-foot candles on the rod mill floor provide ample light for the sake of safety and for ease of operation and repair.

Electric Melting of Alloy Steels

By H. M. GERMAN*

THE first application of melting iron with electric current was made by William von Siemens in 1878, when he melted a small crucible of iron with heat derived from the arc of two carbon electrodes. In 1898, Stassano introduced the first practical electric furnace for steel making; this was followed in 1900 by the Kjellin and Heroult furnaces, and in 1906 by the Girod furnace. A brief description of these furnaces is advisable as modern furnaces are modifications of the above types.

The Stassano furnace is an indirect arc type in which the heat is obtained by radiation from the arcing of three carbon electrodes above the bath. A three-phase alternating current of 150 volts is distributed to the three electrodes. The furnace rotates on an axis inclined about seven inches from a vertical position.

The Kjellin furnace is an induction type using the principle of a step-down transformer. The primary coil is a laminated core wound with insulated copper wire, to which is delivered alternating current of 90 amperes and 3000 volts. The bath of metal in an annular hearth forms the secondary coil.

The Heroult furnace is a direct arc type having a non-conducting hearth. Three electrodes, placed in a triangular position, are suspended through holes in the roof to a position just above the bath. Heat is obtained by the direct action of the arcs on the slag and metal. The three-phase alternating current used is about 10,000 amperes for each phase at from 90 to 150 volts. Some of the modern furnaces are

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equipped to operate with three voltages 150, 110 and 90. The high voltage is used in melting the cold charge, the intermediate voltage after the charge is melted and the low voltage for refining.

The Girod furnace is a direct arc type having a conducting hearth. It is designed to operate either on single phase or three phase currents. The single phase furnace has one top electrode suspended through the roof and the three phase has four electrodes. Current arcs from the electrodes through the slag and metal and passes out of the furnace through soft steel plugs embedded in the hearth.

In the United States, the growth of the electric steel industry is clearly shown in a report of the Iron and Steel Institute showing the tonnage of electric steel produced from 1912 to 1927. In 1912, the total production was 18,309 tons; in 1915, 69,412 tons; in 1920, 502,152 tons; in 1925, 615,512 tons; in 1927, 666,087 tons. The production of alloy steel in 1927 was made up of 284,360 tons of ingots and 59,157 tons of castings, making a total of 343,517 tons. The production of crucible steel in 1927 was 3,189 tons of ingots and 272 tons of castings. From the above figures, it is evident that the electric furnace is fast displacing the crucible furnace as a steel melting medium.

A conservative estimate of the number of electric furnaces in the American Steel Industry is a little over 500; this figure includes furnaces used in both castings and ingot production. Furnaces of the Heroult type are used chiefly in ingot production. A large majority of these furnaces have a rating of six tons capacity but furnaces of one and thirty-five tons capacities are in successful operation. At present, there is under construction a furnace of 70 tons capacity; this furnace is really a double furnace in that it has two sets of electrodes and a single rectangular hearth.

Steel making furnaces are divided into two classes: acid and basic. The acid furnace, which has a silicious lining, is used for melting steels from a charge whose sulphur and phosphorus contents are below the specified requirements of the finished steel. Sulphur and phosphorus are not removed in an acid furnace as their removal requires a basic or lime slag which would seriously attack the silicious bottom. A basic furnace has a basic bottom composed of dolomite and magnesite, and is used for making steels from a charge whose sulphur and phosphorus contents must be partically removed to bring them below specified requirements.

The manufacture of electric steel may be divided into two general processes: the hot metal process and the cold scrap process. In the hot metal process, molten steel from Bessemer or open-hearth furnaces is poured into the electric furnace to be further refined and alloyed. In the cold scrap process, cold scrap is charged into the electric furnace, melted, refined and alloyed. Most of the highest grade alloy steels are made from the latter method. In fact, a large number of buyers specify that the steel be made from a cold charge.

Cold Melting Practices

There are three distinct methods of making steel from a cold charge, namely: melting with complete oxidation, melting with partial oxidation, and melting with little or no oxidation. A brief outline of the above methods is as follows:

Melting With Complete Oxidation

In this method, sufficient ore is added to the original charge to cause the oxidation and removal of all the silicon and manganese, most of the phosphorus ,and the carbon to a given point, during the melting period. If the laboratory report on a preliminary test taken after the charge is melted shows the carbon or phosphorus to be too high, more ore is added until these elements are reduced to the desired amount. Care must be taken that an excess of ore is not added or the bath will become over oxidized which will prolong the refining period and make the removal of oxides from the bath more difficult. After the melting and oxidation period, the heavy black slag is removed. This is accomplished by tilting the furnace forward so that part will run out of the tapping spout; the remainder is removed by pushing it forward with bars and pulling it out with rakes. The complete removal of the slag is controlled largely by the fluidity of the slag. If the slag is too thin it can be thickened by spreading a few shovels of limestone over the bath or if it is too thick it may be thinned with fluorspar. If a medium or high carbon heat is to be made, carbon in the form of ground electrodes or coke breeze is spread over the surface of the bare metal and beat in with iron rods. Lime and spar are then added to build up a slag and when melted coke breeze is spread over the surface to reduce the oxides in the slag and turn it from a dark lime to either a white or carbide slag as desired. The metal at this stage of the process contains a large quantity of dissolved and suspended iron oxides and carbon monoxide gas; the amount depending upon the amount of ore added during the oxidation period and the amount of carbon beat in the bath. These oxides and the gas are removed as far as practical with a strongly reducing carbide slag and the balance by the addition of ferro-manganese and ferro-silicon. The more completely they are removed, the better will be the quality of the steel made. After the slag has been turned white or carbide, another preliminary sample is sent to the laboratory for carbon, manganese, and alloy analyzes, and when received the alloy additions are made.

With the exception of about 50 pounds of ferro-silicon, which is usually added after the slagging off operation to quiet the bath, and tungsten and molybdeum, when they are introduced in the form of tungsten oxide and calcium molybdenate, it is considered good practice to make the alloy additions after the bath is completely or almost completely deoxidized. At some plants, the elements which are not readily oxidized and form solid solutions with iron as nickel, copper and cobalt are added early after slagging off but it is considered better practice to wait until the bath is deoxidized. Chromium should not be added until the bath is deoxidized or some of the chromium will be oxidized and combine with iron oxide to form a double oxide refractory, which is infusible at furnace temperatures. This refractory remains suspended in the metal and cannot be removed. Manganese is usually added after the bath is deoxidized as is also another portion of the silicon; the final silicon addition which should be small is made about ten minutes before tapping. After the above alloys have been added and melted, the bath is well stirred and a sample for final analysis is sent to the laboratory. When the

analysis is returned, the final additions are made; the temperature of the bath is regulated, and preparations made for tapping. Ferro alloys of vanadium and titanium are not added until after the final silicon addition and zirconium is added in the ladle. When making quality steel, it should be made in the furnace and not doctored in the ladle.

The bath, after making the final additions, is in a liquid colloidal condition, in which the iron is the solvent and in which are dissolved certain alloys and in which are suspended various amounts of non-metallic inclusions. A holding period just before tapping is beneficial in that the minute particles of solids and gas will have an opportunity to coalesce into particles of sufficient size so that they will rise to the top by gravity to enter the slag and not remain suspended in the steel in the colloidal form. As crucible steel is dead melted and killed to a point where it is absolutely quiet, the holding period is just another factor in emulating the crucible practice to produce quality steel.

The advantages of this method are: First, that owing to the almost complete removal of phosphorus and sulphur, cheap scrap can be used, and Second, after melting, the bath has a fairly definite composition and the practice can be standardized. The disadvantages of the method are: First, an excessive amount of dissolved oxides from the oxidizing material remain after slagging off which is difficult to remove. Second, recarburizing by the addition of large amounts of carbon produces a reaction between the carbon and dissolved oxides in the bath causing an excessive amount of carbon monoxide gas to be dissolved in the steel. Also, a large amount of ash from the carbonaceous material enters the bath. Third, more alloys are used in recarburizing as all the oxidizable elements are removed in melting. Fourth, as it is almost impossible to remove all oxides and gases from a saturated bath, this method does not produce the best quality electric steel.

Melting With Partial Oxidation

In this practice, little or no ore is added to the original charge; the oxygen for a partial removal of impurities is furnished by the rust and scale on the charge. In melting, all of the silicon and about half of the manganese, phosphorus and carbon are removed. By controlling the furnace temperature, it is possible to remove an additional amount of phosphorus. Some sulphur is removed during melting as manganese sulphide, but most is removed during the refining period. When making high carbon steel, pig iron or coke is added to the charge so that it will melt down high in carbon. After slagging off, a carbide slag is made and the bath deoxidized, degassified and finished the same as in the previous method. With the exception of carbon, which is added in washed metal, the alloy additions are made as in the previous method.

The advantages of melting with partial oxidation are: First, a better quality of steel is made than when melting with a complete oxidation as an excess of oxides, ash, and carbon monoxide is not in the bath to be removed. Quality steel contains only minute quantities of oxides and gases and the best way to keep them out of the steel is not to put them in the bath. Second, less alloys are needed for recarburization as they are not completely removed in melting. Third, the time required for the complete removal of impurities in melting and for refining is considerably shortened. The disadvantages of this method are: First, a better quality of scrap is required; the phosphorus content should not be over .040 per cent. Second, more skill is required of the melter to control the removal of impurities in melting.

Melting Without Oxidation

As the charge is melted down under a white slag, the black slag and oxidation period are absent and slagging off is not necessary. When the charge is melted a sample is taken and sent to the laboratory and the slag turned carbide. As soon as the analysis is returned, final additions of alloys are made and the heat made ready for tapping. This method closely duplicates the crucible practice in melting and has the advantage that some sulphur is removed.

This method possesses the following advantages: First, the highest quality of steel is made. Second, practically all the alloys in the charge are saved, and Third, the time for making a heat is shorter than in the previous methods. The disadvantages of this method are: First, the phosphorus must be low in the scrap. It should be .005 per cent lower than required in the finished steel to allow for the pickup from the bottom, slags, and alloy additions. Second, a smaller charge is used as no second charge is added.

Selection of Method

This is almost entirely governed by the analysis of the available charging materials. If they are such that no oxidation is required to reduce any of the elements to meet the specifications of the finished steel, melting without oxidation should be used. This is the method used in making "remelt" heats; those in which the analysis of the scrap is the same as of the finished steel. If the analyses of the charging materials is such that some of the elements have to be reduced partially, then melting with partial oxidation should be used, but care should be exercised not to oxidize the bath more than necessary to reduce the high elements within specifications; since it is recognized that, as the amount of oxidation in melting increases the greater will be the difficulty to completely deoxidize the bath and the steel will be proportionately poorer in quality. Melting with complete oxidation should only be used when the phosphorus content of the charge is high or when making low carbon steel from high carbon scrap.

Refining Slags

There are two types of refining slags used in the basic electric furnace which are known as white slags and carbide slags. White slag is a mixture of lime, coke and feldspar in approximately the following ratio: 12 to 1 to 2. The amount of coke is so small that calcium carbide is usually absent or to a slight extent occurring in irregular patches near the electrodes. White slags are only slightly reducing and are therefore very weakly deoxidizing and they are not strongly desulphurizing. Their color varies from white to dark grey, depending upon their content of metallic oxides. Refining slags should be kept practically free from metallic oxides for with every given carbon composition of the metal there is an equilibrium critical composition between the

metal and the slag. If the FEo content of the slag is below this critical composition there will be a transfer of FEo from the metal to the slag and conversely, if the FEo content of the slag is above the critical amount, there will be a transfer of FEo from the slag back to the metal. Spreading a few shovels of fine coke breeze or ferro silicon over the surface of the slag will reduce the metallic oxides to their metallic condition when they will re-enter the bath of metal. The use of white slags is only justified when it is necessary to keep the carbon content of the finished steel as low as possible.

Carbide slag is also a mixture of lime, coke and feldspar, but it contains a greater proportion of carbon. An average ratio is 6 to 2 to 1. The amount of carbon may be increase or decreased, depending on whether a stronger or weaker reducing slag is desired. Carbide slags are readily distinguished from white slags by the odor of acetylene when moistened with water. Carbide slags are strongly reducing and are therefore strongly deoxidizing and strongly desulpurizing but are weakly degasifying. The only disadvantages of carbide slags are: that they require more skill to form and maintain than white slags and that they will transfer some carbon to the metal. This carbon transfer, however, is fairly constant and can be controlled. The bath should not be stirred before tapping and the slag should not intermingle with the metal during the passage of the metal into the ladle or slag will be emulsified in the metal and produce dirty steel.

Temperature of the Metal Before Tapping

The temperature of the bath at the end of the refining period and after the final alloy adjustments are made is usually too hot to pour. To lower the temperature, the furnace current is decreased and it is good practice to shut off the power for a few minutes before pouring to obtain a clean separation of metal and slag.

The amount of FEo soluble in the metal is a function not only of its contents of carbon and dexoidizing elements but also of its temperature.

C. H. Herty, Jr., of the U. S. Bureau of Mines has shown that the solubility of 1 per cent of FEo in iron occurs at approximately 2810°F, 1½ per cent at 2950°F., and 2 per cent at 3080°F. In a like manner, steel at high temperatures will hold in solution more gas than at lower temperatures. In cooling, the saturation point decreases and gas is given off. It is therefore, evident, that the lower the temperature at which steel is poured the lower will be its content of FEo and soluble gases. The theoretical low pouring temperature is rarely attained in practice as there are other factors, such as: size of ingots to be made, rate of teeming and rate of solidification of the steel, which must be considered in determining the proper pouring temperature. The ideal tapping temperature is that which will permit the metal to be held in the ladle about five minutes before teeming to insure a clean separation of metal and slag, that which will permit the ingots to be teemed freely without a freezing up of the nozzle and stopper, and that which will cause the formation of a ring skull in the ladle of 100 to 200 pounds.

In conclusion, the writer desires to state that electric steel melting is still an empirical practice. Certain phases of the operation can be standardized, improvements in furnace and laboratory equipment are being made, but, in the making of quality steel, much depends upon the skill and judgment of the melter.

The Placement of Men or What the Plant Surgeon Can Do for Safety

By A. W. COLCORD, M.D.*

I DO not need to waste any time on this audience telling you that the physical and mental condition of the worker have much to do with getting hurt. You were convinced of this years ago. Stoeckel, Commissioner of Highways of Connecticut, has well shown in a recent paper that a large proportion of automobile accidents are due to the mental condition of the driver. This is no more true of motor accidents than of those in our mills. The saying: "A sound mind in a sound body" is as old as civilization. If we accept the newer psychology basing every mental action on an external stimulus and a response through the reflex arc, we may change our saying to: "A sound mind is a sound body."

There are accidents that are accidents in the pure sense of the word. Then there are accidents due to wrong environment of the worker—faulty machinery, poor guards; poor lighting; slippery floors; an untidy mill; the carelessness of the other fellow, etc. But a certain percentage of personal injuries is due to the mental condition of the fellow who gets hurt **at the time** he gets hurt. There may be worry, fatigue, hunger, thirst, loss of sleep, pain, physical weakness, effects of heat, cold, or poison gas. There may be bodily disease as tuberculosis, syphilis, Bright's Disease, diabetes, cancer, heart disease, and so on through the long list. Any of these will tend to make the man let down in his safety habits.

The worker's day is made up of a thousand reflex acts unconsciously done as a result of years of training and experience until they have become fixed habits. The causes above enumerated break into these habits all along the line of efficiency and safety. When a new situation arises one must **think.** Intensive attention is called into action. If this situation involves danger, his safety will depend on his

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alertness—on his ability to keep cool and think clearly in spite of fear and excitement. If we analyze those accidents in group III, depending on the mental condition of the injured at the time of the accident, we will often be able to find the cause. One man had been up all night with a sick child; another had an aching tooth; another was recovering from an attack of influenza; another was developing tuberculosis. There is more than one concrete instance of a passenger locomotive engineer wrecking his train with loss of life and property from a beginning paresis. Syphilis of the brain and nervous system is no doubt responsible for a considerable number of industrial accidents.

I have recently had a severe case of toluol and Benzol poisoning requiring long and vigorous use of the pulmotor to get him to breathe at all—then some two hours of oxygen and a prolonged convalescence. He claims he needed money badly and had starved himself for weeks before the accident. He knew better than to enter alone the chamber containing the poison gases. We don't know why he did it, and believe that this starvation was responsible for three things:

1. His lack of caution.
2. His lowered resistance to poisonous gas which came near being fatal.
3. His slow convalescence.

The question of lowered resistance is a broad one—of great importance to all of us who have to do with safety. There is an interdependence between the effects of the human body of fatigue, hunger, heat, cold, shock, infection, mental strain, poisons, or disease. Each one of these lowers resistance to the rest. A man affected with any one of these has his safety affected in two ways:

1. He is more apt to get hurt on account of less caution and alertness.
2. His resistance is lowered to the effects of any injury. He is more apt to have his wounds infected, is in greater danger of dying from shock or poisons, and will be longer recovering from an injury.

The industrial surgeon can do much to prevent them in two ways:

1. Watch for these hazards in the mill and not only keep the hazard away from the man, but keep the man away from the hazard.
2. Keep the man in the mill physically fit so that when exposed to such a hazard he will have a high resistance.

The first of these covers the whole ground of sanitation and safety as far as these can be influenced by the industrial surgeon. I believe the company surgeon can and should get out into the mill from time to time, study the conditions under which the men work—heating, lighting, ventilation, toilets, rest rooms, lockers, shower baths, drinking water and eating places. He should study special hazards; danger to eyes, wear goggles, colored glasses, etc., are needed; danger to skin from chemicals, oil etc.; danger from poisonous gases or dusts. He should study the exposures to heat, cold, electricity, etc. His contact with the men who come to the emergency hospital will enable him to observe the effects of these various hazards and confer with the management or safety department as to their betterment.

The surgeon should be a valuable member of the general plant safety committee; he should attend all meetings and take an active part. This contact with the general safety committee is one of the most valuable the surgeon has. These men are always interested in safety. It should not be hard for the earnest, enthusiastic surgeon to sell them the idea of better health in industry.

In his talks to first-aid classes, he should devote a certain time to personal hygiene, home sanitation and even community health. One of the valuable things about employment examination is the personal contact with the men. The surgeon can not only find out the man's bad habits and his correctible defects, but he can advise him how to get rid of them. Just after examining a man's heart, a word of warning about his excessive use of cigarettes has a telling effect. It is not enough to teach the men about health. We must **sell** them health. To sell a thing we make a man want a thing he didn't want before—to want it so badly that he will give up something valuable to get it. To sell **industrial health** we must be thoroughly sold ourselves. The industrial surgeon must not stop at the mill. He should make his influence felt through the whole community. The worker spends sixteen hours outside of the mill. What he does and how he lives have an important bearing on his health and safety, and the surgeon should take a keen interest in the employee's family, his wife and his children, the workers of tomorrow. He should direct the work of the welfare nurse in her health teaching in classes and in the homes. He can use clubs, churches, schools, newspapers, boards of health and the other doctors of the town to spread the gospel of good health.

My views on periodical examination have already been given before the National Safety Congress. They have been twice published and may be found in your Transactions of the Milwaukee Meeting of 1920.

It costs about $2,200 to raise a boy in Pennsylvania, send him through the eighth grade of school and get him old enough for a job in the mill. It costs several thousands of dollars to train him for a skilled job. When trained, his earning power for his life expectancy is from $15,000 to $40,000. The human machine, the most perfect of all machines, is the most delicate, the most easily injured. More and more our great corporations are becoming convinced that it pays to conserve their greatest asset, manpower—to examine it periodically, to keep it in repair and to raise it to the highest point of efficiency. Such an examination should include:

1. A thorough general physical examination—chest—abdomen—nervous system.
2. Eyes and ears including vision and hearing tests.
3. Urinalysis and blood pressure.
4. Functional heart test.
5. A Wassermann where syphilis is suspected. Some would do it in all cases.
6. Teeth and tonsils.
7. A follow-up in each case to urge the correction of bad habits; the cleaning up of the mouth and throat; correction of errors of refraction; treatment of curable disease. Especially the case of incipient tuberculosis should be aided in every way—needed period of rest—adjustment of job—care of his family—institutional

care when needed—freedom from want and worry—medical advice as to sunshine, fresh air, climate, food, medicines, personal hygiene, and avoidance of exposing others to contagion.

I am not sure whether it pays and is really wise to have, at the company's expense, our employees' teeth repaired, their diseased tonsils removed, their error of refraction corrected with glasses, and their salvasan given. All these, I feel are still in the experimental stage. The company may aid its men to get this service at a small cost, and if it desires, pay a portion without going to extremes of paternalism. The all important thing is **to follow up every case and see that the men get this service when needed.**

In the placement of men when employed the surgeon and chief employment officer should work together. The prospective job is written at the head of the examination card and the surgeon keeps this in mind when examining the man. When any doubt arises he should confer with the employing officer. There are some jobs that require special fitness, as cranemen or locomotive engineers. The work of this group involves more than usual responsibility with special hazards to themselves, to their fellow-workmen or to property.

The examination should include:

1. An estimate of mentality as to
   (a) Alertness.
   (b) Power of attention.
   (c) Reactions. These should be prompt certain and accurate.
2. There should be freedom from syphilis, epilepsy, apoplexy, alcoholism, drug habit, uncompensated heart lesion, uraemia, or other serious disease.
3. The standard for vision and hearing should be well above that of the ordinary employee.
4. There should be periodical physical examinations—best annually.

In our employment examination, we find three main groups:

1. The sick man—too sick to work—we either defer his acceptance or reject him and try to aid him or advise him as to his care and treatment.
2. The well man—the normal—who grades as well as the average physically and mentally.
3. The subnormal, mentally or physically. If we can use him, we should select his place with care. He should be watched by superintendent and foremen to see how well he does his work; by the surgeon to see how he stands it.

The placement of men after recovery from disabling injury requires unusual tact and hearty co-operation of the management, the employment officer and the department superintendent. These men fall naturally into four groups:

1. Minor injuries with short disability period returning to former work.
2. More severe injuries, usually general hospital cases with prolonged disability. These usually are best put at some light work for a few weeks before going back to the old job. This is "occupation therapy," a very important part of the treatment. It is not good for man to loaf—or, conversely, it is wise to get him back to some kind of work at the earliest moment consistent with his recovery. During this period he is watched and treated and the surgeon and department superintendent keep in close touch. There is a tendency on the part of many men to try to prolong the hospital period, the loafing period and the light job period. The surgeon must cut each of these short at the proper time.
3. In a third group the man is so maimed or crippled that he can never return to his old job, and must be taught another one. A large plant affords ample opportunity for this. Great care should be taken in its selection—it should be one the man likes and is fitted for mentally and physically. One of our brakemen lost a leg. We gave him three years of apprenticeship in our roll shop. He is now a full-fledged roll-turner getting within 2 cents per day as much as he would get as brakeman.
4. A fourth group which is rare in the larger mills consists of men who can find no place in their own mill and must be turned over to the community or the state for vocational training. In my 26 years at the Clairton Mills, I have never found one of these.

If we study the workman in his relations to himself, his fellow-workmen, his employers and the company surgeon, we find four important things that stand out. On these things depends largely his success or failure in life. On these depends almost entirely his value to the company:

1. Loyalty.
2. Health.
3. Efficiency.
4. Safety.

These four things are so interwoven that we can hardly think of one without thinking of the other three. If the company surgeon is the right kind of a man; if he has the confidence of the men in the ranks, of the department superintendents and of the management, he can do much to promote all four. Every contact with the men is his golden opportunity. He may get this confidence:

1. By being fitted by **nature** and **training** to be a real company surgeon, falling in love with his work and putting his soul into it.
2. By having his department organized for efficiency.
3. By being **up-to-date** in **equipment** and **methods.**
4. By securing
   (a) Full support of the management.
   (b) Hearty co-operation of superintendents.
   (c) Obedience of rank and file.
5. By being **square** with every man. **See that he gets "his."** Let the surgeon stand up for the man's rights just as honestly and fearlessly as he does for those of the company. If the man has tried to put across something crooked and deserves penalizing it should be swift and certain.
6. By having a **real interest** in the welfare and happiness of **every man** and his family.
7. By being kind, without coddling, courteous, without being obsequious, painstaking, dignified and firm.
8. By **making good**—getting results—"Nothing succeeds so well as success."

What Happens in Couplings; Fatigue of Materials; What It Is and How It Occurs in Flexible Couplings

By H. F. MOORE*

"FATIGUE OF METALS" is the rather inappropriate term given to the fracture by gradually spreading cracks, which sometimes occurs in machine parts subjected to thousands of repetitions of loading. A crude example of "fatigue" failure is the breaking of a piece of ductile iron wire by bending it back and forth. In this simple illustration, familiar to everyone, it will be noted that, though the wire is made of ductile metal, yet when it breaks it breaks square off without any noticeable stretch,—a sharp contrast to the long stretch which occurs if the wire is broken by a steady, heavy pull.

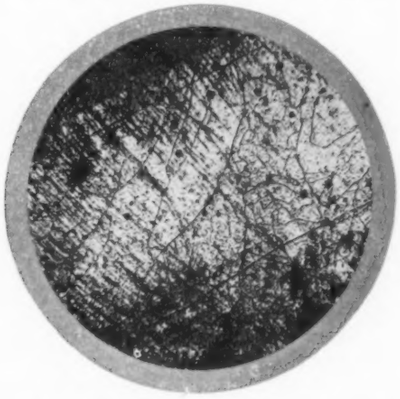

FIG. 1—Photomicrograph of Fatigue in a piece of iron. The piece has been bent back and forth some 400 times. Magnified 100 diameters.

Figure 1 shows a photomicrograph of a piece of iron which has been bent back and forth some 400 times, and in it there can be seen a number of fine cracks, extending into the metal like minute hacksaw cuts. When these cracks have spread far enough, then the remaining cross-sectional area of sound metal is not sufficient to carry the working load, and the piece fractures suddenly, just as a piece of metal in a power hacksaw fails suddenly when the saw has cut almost through.

Common Misconceptions

Several misconceptions concerning "fatigue" of metals are rather common and may be noted here.

It used to be held that under repeated stress metal "crystallized,"—changed its internal structure from a "fibrous," ductile substance to a "crystalline," brittle one. This view has been thoroughly discredited since the use of the metallurgical microscope has become general. All structural metals are seen to be made up of crystalline grains, and under repeated stress no appreciable change occurs in this structure, but if the stress is high enough the structure of the metal is broken up by spreading cracks like those shown in Figure 1.

It is rather natural to suppose that **ductility** in a metal increases its resistance to repeated stress. Ductility is important in that it allows metal to be bent cold without fracture, but ductility does not directly increase fatigue strength. An example of this is furnished by spring steel. Springs are designed to resist severe repeated stress, and the material used in them is a hard, strong, brittle steel rather than a soft, ductile steel. Under repeated stress ductile metal fails as readily and as suddenly as brittle metal. Wrought iron, soft steel, soft copper, aluminum,—all these metals show fatigue failures as well marked and as sudden as do spring steel or cast iron. Strength and uniformity of structure count in resisting repeated stress, rather than ductility.

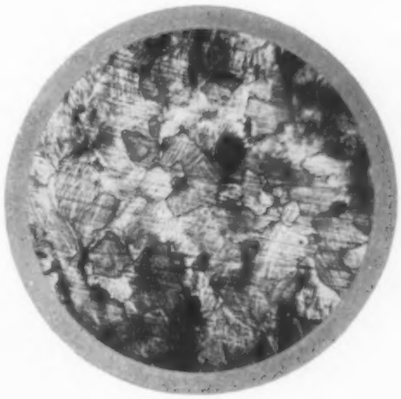

FIG. 2—"Slip Bands" in a piece of iron subject to a load beyond the elastic limit. Magnified 100 diameters.

Slip in Metals

Another common idea is that the **elastic limit** of a metal is a measure of its fatigue strength. The elastic limit of a metal marks the beginning of an internal disturbance quite different in its nature from the spreading cracks which constitute fatigue failure. This disturbance is known as "slip" and consists of the sliding of layers of metal within the crystalline grains, like the sliding of boards in a pile, or of cards in a pack. Under the microscope this sliding shows up as a series of "slip bands," such as are shown in

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Figure 2. These slip bands mark the edges of the slipping layers—the edges of the cards in the pack, so to speak.

In some metals, slip may occur repeatedly without the opening up of fatigue cracks, and in other metals fatigue cracks open up with very little evidence of previous slip. Slip marks the elastic limit of the metal, the limiting stress above which appreciable inelastic action becomes evident. For some metals the strength under repeated stress,—the "endurance limit" or "fatigue limit"—is higher than the elastic limit, while for other metals it is lower. Copper furnishes a striking example; for annealed copper the fatigue limit is higher than the elastic limit, while for cold drawn copper the reverse is true. No general rule can be laid down for predicting for any given metal the relation between slip and spreading fracture,—the relation between elastic limit and fatigue strength.

The fatigue strength of a metal seems to be fairly closely related to its ultimate tensile strength, although the fatigue limit is always much lower than the ultimate tensile strength. This is not surprising when it is remembered that fatigue failure is a spreading fracture,—the actual progressive tearing or shearing apart of the metal.

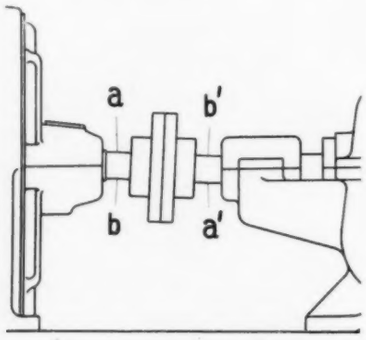


FIG. 3—Flexural stresses in misaligned shaft go through a complete cycle of reversal at each revolution.

Effect of Reversing Stresses

The most dangerous form of repeated stress occurs when the stress is completely reversed. A shaft supported in several bearings which are not perfectly aligned is subjected to reversed flexural stress, as is shown in Figure 3.

When the shaft is in the position shown there are set up tensile stresses at a and a′, and compressive stresses at b and b′. When the shaft has turned half a revolution from the position shown, the metal which was initially at a and in tension, is now at b and is in compression, an analagous reversal of stress occurs for the metal initially at a′. That is, for each revolution of the shaft there is a complete cycle of reversed bending stress. Such a shaft is subjected to millions of cycles of reversed bending in a few days of continuous service.

This condition of reversed stress due to misallignment of shafting is quite common, since bearing alignment is rarely perfect at the time of installation and still more rarely stays perfect. Not only are severe stresses set up in the shafts due to misalignment, but the bearings are unduly loaded in a manner which is often difficult to determine but which bears a direct relation to the degree of misalignment. The result is that some bearing (or bearings) is greatly overloaded, manifesting this overload by "running hot" and sometimes failing completely.

Function of Flexible Coupling

To avoid the bending stresses in shafting and excessive pressures on the bearings there have been devised various types of special couplings. These are usually spoken of as "flexible couplings," although the term "alignment" couplings would be more suitable

In one class of flexible couplings, reversed bending in the shaft is avoided by inserting special connecting parts which are flexible,—pieces of rubber, leather or of thin steel. Flexible elements which

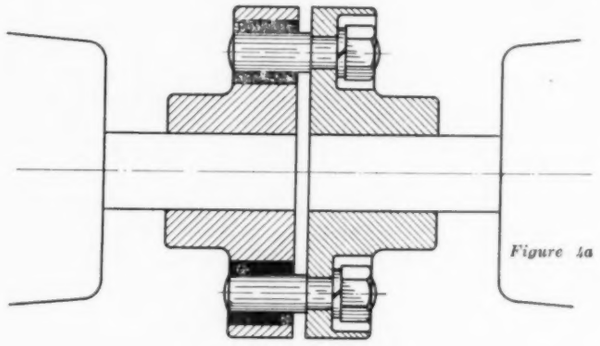
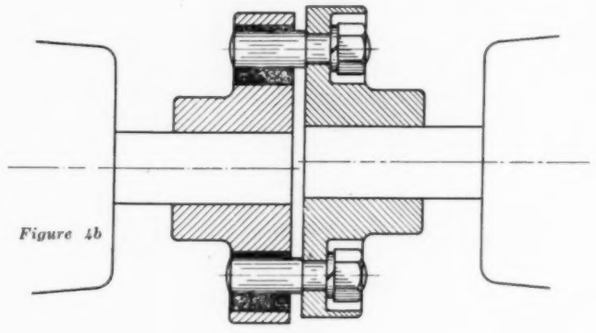


FIG. 4A-4B—By use of flexible bushings, subject to alternate compression and expansion, flexibility is obtained at the expense of the rapid fatigue of the flexible material.



consist of discs or bushings of rubber or leather allow a certain amount of bending action in the coupling by their ability to "give" under load. A coupling with such flexible elements is shown in Figure 4. When the shafts are in perfect alignment the bushings are subjected to direct compression only (Figure 4a). When the connected shafts have their axes parallel, but not concentric (Figure 4b), the bushings or discs are compressed first on one side then on the other as the coupling revolves. When the shafts are both offset and are not parallel the bushings or discs are compressed first at one end, then at the other. The rather severe compression of the rubber or the leather does not, it is true, cause the sudden fatigue fracture which sometimes occurs in metal parts under repeated stress, but there is frequently caused a permanent distortion in the rubber or the leather, and, especially in rubber, a gradual loss of "spring" in the material. This means that unless the bushings

or discs are renewed from time to time they will gradually lose effectiveness as flexible elements.

Another type of coupling uses as the flexible element some form of spring, e. g.,—a flat spring as shown diagrammatically in Figure 5a or a disc spring as shown diagrammatically in Figure 5b. Such spring connections are subjected to a complete reversal of bending stress for every revolution of the coupling. In Figure 5a and Figure 5b the parts of the springs marked T are on the tension side of the bent spring, and the parts marked C are on the compression side. It will be seen that, as the shaft rotates one-half revolution, the stress in these parts of the spring changes from tension to compression, or vice versa. No matter what form the springs or discs take, they are subject to this reversal of stress at each revolution.

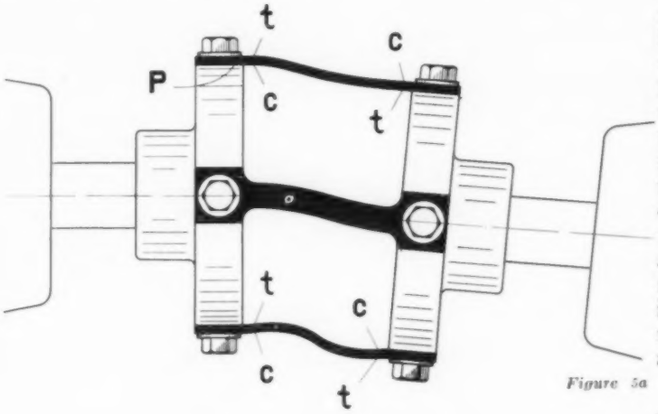


Figure 5a

FIG. 5A-5B—The use of various types of steel springs, discs or grids, depends for flexiiblity upon the rapid reversal of stresses in these units, resulting in fatigue.

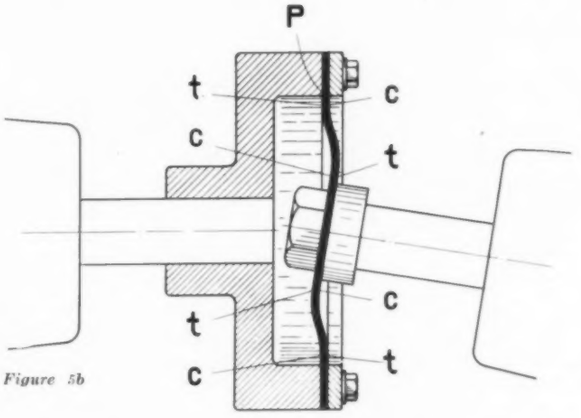


Figure 5b

Stresses in the Flexible Members

Now, as previously noted, this complete reversal of stress sets up the condition most favorable to starting the spreading cracks which constitute fatigue failure of the metal,—a failure occurring suddenly without warning. Moreover, at the points where the springs bear on the coupling flanges (such as P, Figure 5a and Figure 5b) there is a tendency for the edge of the flange to "dig into" the spring, setting up a heavy localized stress and tending to wear a sharp notch in the metal, which greatly increases the danger of fatigue failure. This localized stress at bearing points of flange and spring comes at locations where the reversed bending stress is also high, and the combination makes the design of satisfactory couplings with flexible spring elements a matter of no small difficulty.

Fallacy of "Stored Energy"

An advantage claimed for such couplings is that under suddenly varying power requirements energy can be stored in the bent springs, and the suddenness and magnitudes of shock loads reduced. This is true, but the amount of energy which can be stored in springs of feasible size is not large. Under direct tension or compression, spring steel can safely store up about 4 foot pounds of energy per cubic inch. A thin circular tube under torsion can store up nearly as much per cubic inch; a solid circular shaft in torsion equivalent to a helical spring in compression or extension can store up less than half that amount; while a flat spring under flexure can store up safely an amount of energy varying from about 0.5 to 1.5 foot pounds per cubic inch, depending on the manner in which it is loaded. Flexible couplings with spring members are, in general, very inefficient for the storage of the energy of sudden shocks.

The actual magnitude of the stress set up in the spring members of a flexible coupling, or of the capacity for storing energy in them, is a matter for computation by the formulas of Mechanics of Materials. Suffice it to state that only a slight amount of flexure is necessary to set up high stresses, and it is again to be noted that the stress concentration at bearing points of springs may greatly increase the stress (sometimes by as much as 100 per cent) over that computed by the ordinary formulas of Mechanics of Materials.

The accompanying table gives average values of fatigue limit and of energy storing capacity (resilience) for various common metals.

Fatigue Limit and Energy Storing Capacity for Various Metals

METAL	Fatigue Limit Under Reversed Flexure (Pounds per sq. in.)	Energy Storing Capacity (Resilience) under direct Tension or Compression* up to Fatigue Limit (Foot pounds per cu. in.)
Wrought iron	25,000	1.0
Structural steel	30,000	1.3
Machinery steel, normalized	35,000	1.8
Carbon spring steel, heat treated	50,000 to 90,000	3.6 to 11.7
Alloy spring steel, heat treated.....	70,000 to 120,000	7.1 to 20.8
Cast iron	10,000	0.7
Hard-drawn copper ...	10,000	0.6
Hard-drawn brass	30,000	5.8

*As noted in the text, the capacity per cubic inch for a helical spring of round wire is somewhat less than half the above figures, while the capacity per cubic inch for a flat spring under flexure varies from about one-ninth to one-third the above figures, depending upon the manner of loading. The capacity of a metal for the elastic storage of energy varies directly as the square of the safe stress, and inversely as the modulus of elasticity.

Elimination of Flexible Materials

For transmitting large amounts of power it is evident that a coupling which secured flexibility by means of sliding members would have advantages in strength over one which used springs or discs to secure flexibility. Figure 6 shows diagrammatically such a coupling. The floating connecting member A is fitted with projections at each end which mate with slots in the shaft flanges. There must be clearance enough between projection and slot to allow slight

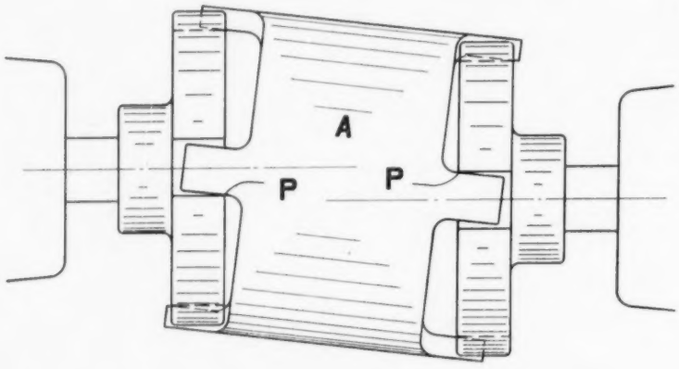


FIG. 6—Diagramatic design of a coupling wherein use of flexible materials in any form is eliminated.

angular displacement, and some longitudinal motion must also be possible. With this coupling there would be a **repetition** of stress in the same direction during successive revolutions, but not **reversal,** a condition which markedly reduces the probability of fatigue failure of the metal. In the coupling shown in Figure 6 there would be a good deal of lost motion between slots and projections, and, unless there were thorough lubrication, projections and slots would wear very seriously. Moreover, as shown, there would be a tendency for "digging in" where a corner of a slot bears on the side of a projection, with consequent high localized stress.

Refinement of Design

Developing this crude jaw type arrangement, a more satisfactory form is arrived at as shown in Figure 7. The jaws, or load-carrying surfaces are located on the periphery of the driven and driving members, engaging with slots on the interior circumference of a floating sleeve. From the diagrams (Figure 7) it can be seen that offset, angular or both forms of misalignment can be compensated for by this arrangement.

Commercial Application of Principle

Figure 8 shows a commercial development of this floating sleeve principle—Fast's coupling—in which compensation for misalignment is secured without the use of springs subjected to reversed stress, and in which smoothness of action is secured and stress-concentration is avoided by the use of accurately cut-load-carrying surfaces immersed in oil.

The floating connecting member of this coupling is in the form of a hollow sleeve, and is fitted with internal load-carrying surfaces C E at each end. The shaft hubs AA are fitted with load-carrying surfaces B which engage the internal surfaces. The number of surfaces of the shaft hubs and of the internal sleeve is the same. Both sets of surfaces are cut on a Fellows gear shaper, and have a slight backlash (about 0.005 inch).

As the coupling rotates, while the shafts are misaligned there is some repetition or variation of load from surface to surface, but no reversal of flexural (or other) stress. The pressure between the load-carrying surfaces is spread over a considerable area by the presence of an oil film which actually transmits much of the pressure. The short, stubby surfaces aid in minimizing bending stresses.

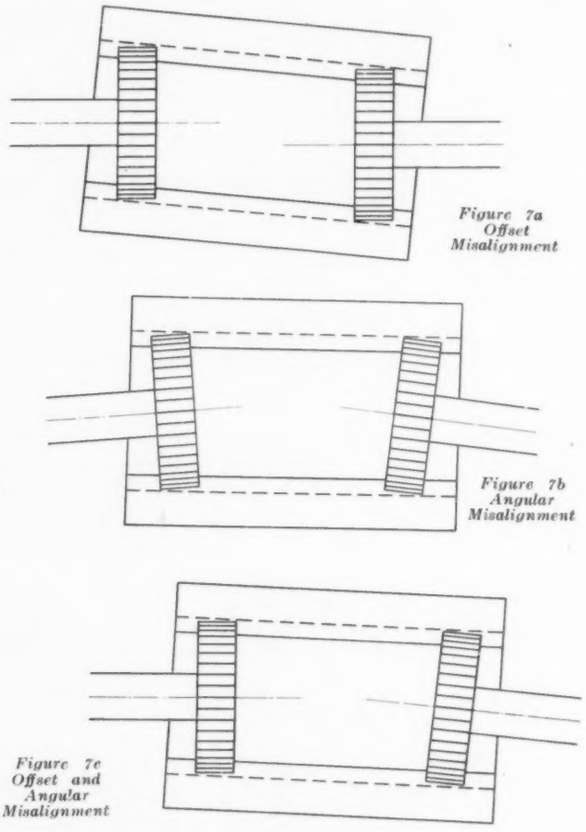


FIG. 7—By locating the load carrying surfaces on the periphery of driven and driving units, compensation can be accomplished by use of a floating sleeve.

Oil As A Load-Carrying Agent

In Fast's coupling a heavy oil is poured into the space between the bottom side of the shaft hubs and the inside of the sleeve, filling this space up to a point slightly above the level of H (Figure 8). At H is the bearing of the sleeve on the shaft hub, a bearing narrow enough to allow slight tilting action, and one holding the end of the sleeve concentric with its shaft hub. As the coupling rotates, the oil is thrown outwards by centrifugal force, and is forced into the small spaces between the load-carrying surfaces, forming a film between them. This oil film performs a very important function as a distributor of pressure from surface to surface, and eliminating actual wear of metal on metal. The extent to which an oil film can carry load has been strikingly illustrated by the success of the Kings-

bury thrust bearing, in which there is formed a film capable of carrying quite high pressures without actual contact of metal on metal. In Fast's coupling the centrifugal force, tending to force oil into the small spaces between the load-carrying surfaces, produces somewhat the same effect as is produced by the inclined surfaces of the Kingsbury bearing. As the coupling rotates there is a slight shifting of contacts of the load-carrying surfaces, and this shifting tends to prevent pressure at any one point continuing long enough to squeeze out the oil film entirely.

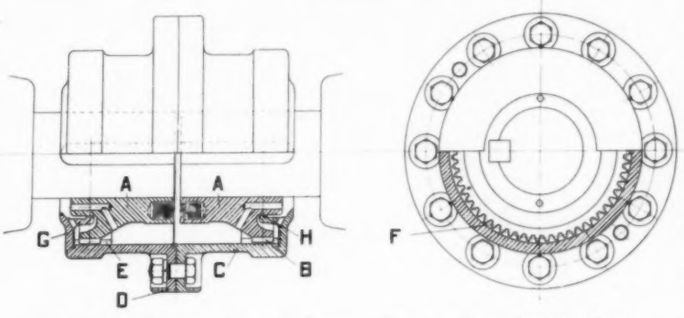


FIG. 8—The design of Gustav Fast, using the floating sleeve principle.

The oil film in the coupling serves, then, three useful purposes: lubrication, prevention of metal-to-metal wear, and distribution of pressure over a considerable area, which diminishes localized stress at points of pressure.

Angular flexibility of the coupling involves, of course, a slight misalignment of the load-carrying surfaces, but this misalignment is only a small fraction of the misalignment of the shafts, and the backlash space allows sufficient angular motion. The internal load-carrying surfaces are given a greater length along the floating member than the length of the surfaces on the hubs, thus making allowance for axial motion.

Necessity For Alignment Couplings

Some months ago the writer saw a dramatic illustration of the necessity for the use of a carefully designed alignment coupling for shafting.

In a drainage district pumping plant a large centrifugal pump was driven by an internal combustion engine. The equipment did not include a flexible coupling between the engine and pump. After some months' service cold weather set in, the alignment of the shafts and engine and pump became imperfect, and there were set up reversed stress conditions such as are shown in diagram in Figure 3, page 5. One day the shaft suddenly fractured near the crank pin of the engine. The engine was completely wrecked, and only the toughness of valve gear mechanism prevented a heavy flywheel from wrecking the building.

The accident gave a vivid warning of the necessity of guarding shafting against the danger of fatigue failure caused by misalignment. The cost of a good self-aligning coupling would have saved the cost of the whole engine.

Increased Requirements of Switching Equipment Due to Increased Service Capacity *

By W. H. ANDREW†

A NUMBER of the larger steel mill plants were originally designed and installed on the basis of their then immediate requirements which they have since far outgrown. The increase in power demand has been rapid during the last few years, and the additional electrification of old steam drives had added to the complications and difficulties in the way of handling the increased power. This increase of power has been so great that in many cases it has been necessary to purchase power to meet requirements. Proper protection of the electrical system has become a problem of paramount importance. It is becoming more recognized that the electrical system is as important as the prime mover or the mill motor. It is a link in the chain and must be as strong and immune from failures as the units that generate and the units that transform the generated current into mechanical energy. It is said that no chain is stronger than its weakest link, if this is to be followed then the switching equipment must be designed and installed to meet the maximum stress that it will be called upon to withstand. The additions of new sub-stations for electrically driven mills, new isolated generating plants and the purchase of power from the utility companies has gradually effected the existing systems. These additions have necessitated new lines and increased the duty on the oil circuit breakers and switching equipment. As a result these plants have reached a point where some steps must be taken to insure continuity of service at all substations at all times. To accomplish this it will be necessary in most cases to make extensive and probably expensive changes in the switching equipment. This, however, cannot be avoided if shut downs, with their accompanied embarrassment, loss of production and the breaking of delivery promises are to be reduced to a minimum. The switching equipment is the heart of the electrical system and without adequate switching, failures will shut down the plant with resultant heavy losses, due not only to failure and damage to equipment, but also the loss in production. Additional money spent for improved

†Westinghouse Electric & Manufacturing Company.
*Presented before Philadelphia Section, A. I. & S. E. E.

switching apparatus is good insurance against loss of production.

Some of the large plants have many of their lines equipped with oil circuit breakers which are obsolete and entirely inadequate to give protection in cases of short circuit. In order to give proper protection the circuit breaker must fulfill the following conditions:

(1) Be of sufficient voltage rating to withstand surges and also have sufficient margin to combat dirt conditions. Practically all steel plants have standardized on using double voltage circuit breakers, i. e., use a 15,000 volt breaker on a 6,600 volt circuit, etc.

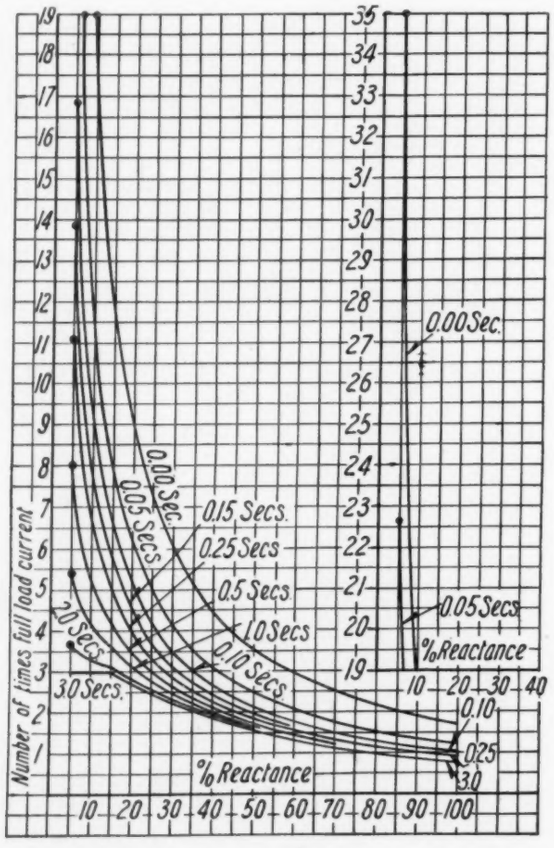


FIG. 1—Asymmetrical single-phase line to line short-circuit currents for use in calculating oil circut-breaker interrupting capacity on polyphase systems.

(2) The interrupting ability of the circuit breaker should be equal to the greatest transient disturbance of the system which can occur at the point of application of the circuit breaker when the system is short circuited. Advantage may be taken, however, of the time delay of the circuit breaker mechanism and protective relay. This delay usually takes from 0.25 to 0.5 seconds.

The interrupting ability of the circuit breaker depends upon its mechanical construction, which must be adequate to withstand the stresses set up under the opening of a short circuit.

(3) The momentary and 5 second ampere capacity of the circuit breaker is also very important. As mentioned under the preceding condition, advantage is taken of the time delay introduced from the instant of short circuit to the actual parting of the circuit breaker contacts. However, during this period the maximum rush of current with its magnetic forces in the direction to decrease the contact pressure and also to force the ends of the stationary contacts apart, must be withstood and all heat absorbed by the contacts.

In revamping a system, a number of less important feeders having smaller circuit breakers are grouped under the protection of a larger circuit breaker. This is called a group system. The smaller circuit breaker must in all cases have a thermal capacity equal to the interrupting ability of the group breaker. The feeder circuit breaker, being held

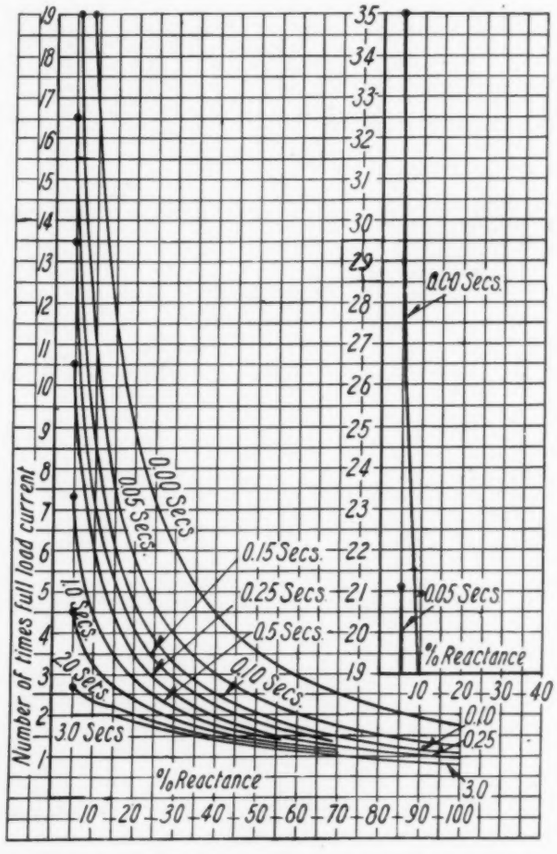


FIG. 2—Asymmetrical three-phase short-circuit current for use in selecting relay settings on polyphase systems.

closed on short circuit, must withstand the thermal effects produced while the group breaker opens the short circuit.

(4) The oil in the circuit breaker must also be considered. The oil in an oil circuit breaker serves as a liquid insulator of high dielectric strength, which will quench the arc formed between the stationary and movable contacts when the circuit breaker opens under abnormal conditions. The intensity of the arc formed when opening contacts under load depends upon the amount of current, the voltage and the rate of separation of the contacts. The heat of the arc vaporizes a small portion of the arcing contacts and some of the oil immediately surrounding the arc zone, with the consequent formation of gas and particles of carbon and copper. The amount of these products depends upon the energy

interrupted. The gas which is formed is immediately displaced by the oil which surrounds the contacts, and the arc is quenched at a succeeding zero value of the current wave.

Each time an oil circuit breaker opens a circuit under load some carbon is formed. Hence repeated operations will in time make it necessary for the oil to be purified. When the oil is free from water the particles of carbon will gradually fall to the bottom of the tank. Carbon and water have, however, an affinity for each other and when both are present they unite, remaining to a large extent in suspension in the oil.

The electrostatic field around the contacts tends to draw the carbon towards them and deposit it upon the insulation near by, reducing the resistance over the surface of the insulation. The dielectric strength of the oil is, therefore, very important to the successful operation of the oil circuit breaker. The dielectric strength of the oil should be at least 22,000 volts. Oil having a dielectric strength of 22,000 volts contains about seven parts of water to one million parts of oil by volume, or one drop of water to about two gallons of oil. The addition of one more drop of water, uniformly distributed in this quantity of oil, will lower the dielectric strength to about 18,000 volts at which value the oil should be dehydrated.

The principle causes of deterioration of the oil in circuit breakers in service are water and carbonization of the oil caused by the opening of the circuit breakers under load. Insulating oils are not hydroscopic, but they may receive water through condensation on the surface of the oil or on the inside of the tank due to the introduction of moist air. The carbon reduces the dielectric strength of the oil, lowers the surface resistance of the insulation and tends to hold in suspension in the oil any water present. These effects are especially to be guarded against in cold weather as, on account of the great viscosity of the oil at low temperatures, carbon is not as readily dispersed through the oil.

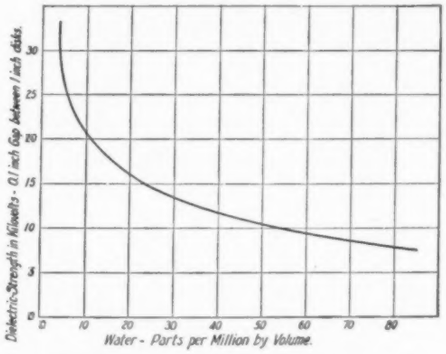


FIG. 3—Relation between dielectric strength and amount of water in insulating oil.

Many users of oil circuit breakers have not given them the attention they should receive, especially as regards the quality of oil; but are now becoming convinced of the necessity for periodical inspection and testing of the oil and of purifying it when necessary to maintain it in good condition. Convenient apparatus for clearing and purifying oil is now available. When a schedule of periodical inspection and testing is followed the best results with the apparatus and the greatest economy in the use of oil are obtained.

The frequency of inspection and testing depends upon the service to which the circuit breakers are subjected. These which operate frequently under heavy loads require more frequent inspection and purification of the oil than those subjected to lighter duty.

A schedule for inspection should be prepared, based upon the operating conditions. The period of time between successive inspections should never be longer than six months.

Summarizing, (1) It is essential that the proper oil level be maintained, as low level may cause a flash-over at the bushings or failure to open heavy overloads properly. Considerable change in level may be caused by change in temperature, rupturing of heavy currents, or possibly leakage of oil.

(2) The oil should be tested regularly for dielectric strength and purified when the tests show it to be necessary.

(3) Contact inspection should be made periodically, especially after the breaker has opened a severe overload or short circuit. This check is very important if the temperature of the breaker is to be kept normal. A circuit breaker reaches its final temperature quickly with a steady current load, so it is a maximum rated device. Thus, if the contacts are not making good contact excessive temperature rise will result, even though the breaker is not carrying rated current.

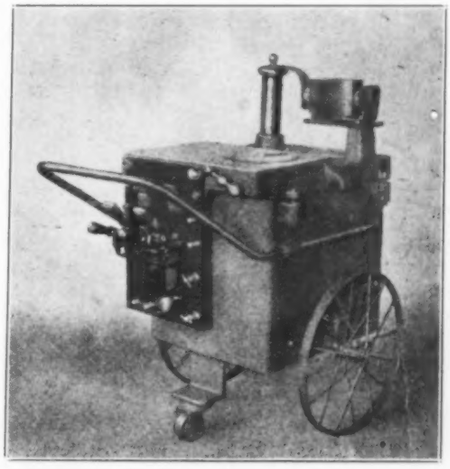


FIG. 4.

Connected with the circuit breaker problem are the disconnecting switch, current transformers and bus bars. These types of apparatus are subject to the same mechanical stresses, and must be likewise immune from failure if continuity of service is to be maintained. In many plants the generating capacity has been greatly increased, but the original installation of the above line of apparatus has undergone very little change. In most cases the original installation was of quite small capacity, so there is little doubt that there still exists apparatus of this class in service which is not mechanically safe for present capacity and from an electrical standpoint does not conform to the present day standards. Disconnecting switches that are not fitted with mechan-

ical locks have a limit to their safe carrying capacity under short circuit conditions. The folowing table gives the maximum current in amperes that can be carried by unlocked disconnecting switches.

100 amp.	5000 amp. max.		
200 amp.	9000 amp. max.	800 amp.	17000 amp. max.
300 amp.	10000 amp. max.	1200 amp.	20000 amp. max.
400 amp.	12000 amp. max.	2000 amp.	27000 amp. max.
600 amp.	15000 amp. max.	3000 amp.	32000 amp. max.

Irrespective of whether a disconnecting switch is used for indoor or outdoor application, a latch that is not positive and entirely dependable is a source of great annoyance. Latches such as the following come under this classification:

(a) A latch which gives no positive indication to the operator that it is fully engaged.

(b) A latch that blows open on heavy short circuit, because of faulty design or magnetic material used in its construction.

(c) A latch which is difficult to operate surely and quickly.

(d) A latch which in time destroys proper contact and alignment of blade and jaws.

(e) A latch which is flimsy in construction and will not stay in adjustment.

With a short circuit of fifty times its normal current rating, a magnetic repulsion of about 450 pounds is set up at the break jaws of a back connected, 2,000 ampere, 25,000 volt switch, tending to blow it open. The amount of this force depends on the size of the switch, its capacity rating, and the arrangement of the buses to which it is connected. Positive latches are, therefore, recommended for practically all applications where single pole switches are hook stick operated.

For current transformers there is little to be said. The general design has adequate mechanical strength. However, these is likewise a limit to what this apparatus will carry. For mechanical strength, a figure of 40 times the current transformer rating is the limit without additional reinforcing. The reinforcing is accomplished by completely surrounding the transformer primary coil with bracing in such a way as to completely secure the coils. The thermal capacity of a current transformer as laid down by the A.I.E.E. Rules is forty times the current transformer rating. The present day design allows a maximum of approximately fifty times the rating, so generally speaking no trouble will be experienced with this apparatus. It is, however, sometimes necessary where small capacity equipment is connected to a large power system, to provide special transformers. Especially is this true where relay protection is important.

The main bus bars in general are least likely to fail under short circuit conditions, as it is general practice to use sturdy construction. However, there may be cases where distribution buses or even power house buses are not equal to the stresses set up under short circuit conditions. The following alignment chart for calculating the force between conductors under the worst condition will be of valuable assistance. The values obtained from this chart will be in pounds per lineal foot. The mechanical stresses due to short circuits on the bus bars must be considered in selecting the type and size of support. These short circuit stresses may depend on the maximum ampere load, under short circuit conditions, the distance between center lines of bus bars, and the relative location of the bus bars.

The mechanical strength of a bus bar support frequently used for heavy duty may be taken as follows: Cantilever, 1500 pounds, load applied 2½" above top of insulator. Tensile, 3,000 pounds. These values will differ somewhat with different manufacturers, but they may be taken as an average. The above values apply only to insulators having cemented top and bottom fittings.

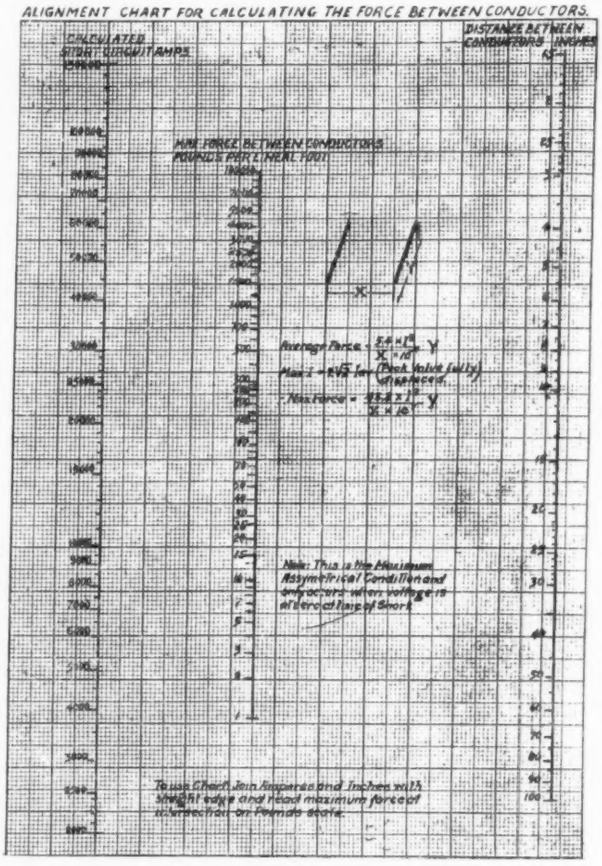

ALIGNMENT CHART FOR CALCULATING THE FORCE BETWEEN CONDUCTORS.
CALCULATED SHORT CIRCUIT AMPS.
DISTANCE BETWEEN CONDUCTORS INCHES
MAX. FORCE BETWEEN CONDUCTORS POUNDS PER LINEAL FOOT
Note: This is the Maximum Asymmetrical Condition and conductors when subjected to electrical fault of short

FIG. 5.

In conclusion, the following illustrations will serve to emphasize the importance of the facts brought out in this paper. Several cases are on record of failure of equipment due to inadequate breaker protection. In one case the equipment was operating under normal conditions, the weakness of the equipment being fully known and instructions issued to the operators to carefully watch loads on individual circuits. The instance in question, the operator was observing the load on a certain feeder to a large motor in the mill rising to dangerous proportions. On one of these overloads he deemed it necessary to take the motor out of service and naturally tripped the feeder oil circuit breaker while carrying this heavy overload. It will be borne in mind that the service imposed on this feeder oil circuit breaker was nothing more than ordinary. However, this breaker completely blew up and caught fire. In addition an arc was started across the three risers to the bus bars which traversed the complete structure—also jumping on to the back of the switchboard and shoot-

ing flame out of every available hole in the slate panels. The arc finally extinguished itself and on examination of the equipment several disconnecting switches were found open as they were not equipped with locks, the whole of the back of the switchboard had a white deposit, but fortunately none of the control leads were damaged. Needless to say this incident caused a complete shutdown. This shutdown was very costly as the expense involved to again get the mill in production was considerably more than the cost of new equipment advantageously installed.

The second case was due to the lack of maintenance on the oil circuit breaker. In this instance a turbo-generator stator went down, the generator in question being differentially protected. The breaker failed to open and was completely destroyed due to insufficient thermal capacity; fortunately, in this case the remaining units tripped out automatically and saved the situation; further, this plant, at the time of the failure, was operating at reduced capacity, so the loss of this one unit and control equipment was not so serious. The plant was again in operation as soon as the disabled generator feeder circuit could be completely disconnected from the main bus bars.

In another instance the failure was very disastrous and was also due to inadequate breaker capacity. In this case several failures occured practically simultaneously so it was difficult to determine what started the trouble. However, a complete plant shut down resulted with extensive damage to the equipment. This plant in the last few years has added considerably to its installed capacity to take care of requirements, but the breaker situation has not been fully revamped. Fortunately the main bus was very little damaged and after all circuits in trouble were isolated and temporary connections made the plant was again put in operation.

In all of the above illustrations the oil circuit breakers were quite capable of carrying their normal circuit load but it will be seen this is not the determining factor for its correct application.

Automatically Opening and Closing Receptacles Containing Inflammable Fluids

By WALTER GREENWOOD*

THE efficiency of any such device can best be determined by practical demonstration. This should be conducted by someone familiar with the method of generating static electricty and causing its discharge, also methods of producing a combustible gas mixture from inflammable liquids that could ignite from the small spark of a static discharge. I think someone could be found who is qualified for making such a demonstration.

There are so many factors involved in producing ignition of gas from discharges of static electricity generated by flow of gasoline through a conduit that it might require repeated effort, even when condititons were considered ideal, for producing one. However, it is a known fact that ignition of light inflammable fluid can be caused by discharge of static electricty, therefore, we must assume there is a potention hazard in every operation where possible ideal conditions for ignition exist when discharging light gravity highly combustible liquid through a conduit.

On former occasions I have dwelt on the subject, "grounding," the only known method for positively avoiding accumulation of electricity that forms a static charge. This subject is so broad it would require a very extensive treatise to make it comprehensive in every detail. It seems proper to here repeat the most important details of correct methods of grounding, also to point out some of the mistaken ideas that are prevalent. Under this latter head it is a mistaken idea to think that a trailing chain attached to a tank truck, under all conditions furnishes a satisfactory ground; that a tank car on a railroad track is always grounded through the track rails; that tank trucks are perfectly grounded unless the nozzle of the discharging hose is electrically connected to the tank and, that a static charge cannot be generated in an automobile, discharged through the grounding of tank car or the piping and tanks of a filling station, where they are properly grounded. It must be borne in mind a static charge can accumulate in an automobile when it is traveling, therefore, absolutely perfect conditions require grounding be applied to an automobile when filling its tank as well as to the container from which it is filled.

A hose made of any pliable material is the ideal conduit through which the flow of combustible fluid can generate electricity. It is momentarily stored in such material before discharging unless a grounding circuit is provided for it to escape through. Such hose should be provided with an electrical connection between its nozzle and its tank connection. With hose known as armored hose, the armor should be connected to the nozzle, and union connection at the tank. Where filling hose is reinforced with special wound wire between plies, this wire should be connected to the nozzle and tank connection. Assuming the hose, filling station pumps and tank and tank cars to be properly grounded, the receptacle to be filled should also be grounded to avoid a static spark jumping from it to the hose nozzle,

*Safety Engineer, Carnegie Steel Co., Youngstown, O.

which spark might ignite any inflammable gas through which it travels.

Knowing the fundamental principles of grounding and knowing these are not always nor even generally complied with, the question of safe-guarding against the unavoidable presence of opportunities for ignition by other means than complete grounding deserves consideration. It seems as though some kind of seal that would automatically close the openings of a receptacle would be useful for two reasons. First, to avoid carelessness about closing the opening after filling such receptacles as they may be applied to, second, to quench an ignition that might occur from any cause by shutting off the oxygen that supplies combustion. Without doubt, in many cases their installation is justifiable, possibly in all cases. It must be remembered ignition does not occur with every seeming possibility but if it can occur where any possibility exists a device for quick closing should be generally installed.

Repeating in substance what was said in a former paragraph, the worth of such a device should be determined by practical tests before it is condemned.

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*Annual Report of Committee on Applications to Iron and Steel**

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

To the Board of Directors:

Your committee is pleased to present the following statement covering the progress of development in applications in the iron and steel industry during the year ending July 31, 1928.

Constantly during this period, the iron and steel industry has added to its general electrical equipment. These general additions have been towards the modernizing of existing installations quite as much as anything, and all effort is directed steadily towards reduction in production costs by addition of improved machinery.

The tendency to increase blast furnace equipment is not present, and this may be said to be true generally of the fundamental processes of smelting iron ore, in coverting iron into steel or in rolling the steel into the promary shapes. Such electrical addition as have been made in the foregoing are in the nature of changes of older equipment to modern.

The principal interest during the current term has been in the finished product mills, which we shall term the secondary mills.

Predominant in this regard are installations in strip mills and in cold rolling, these electrical installations being modern and recording definite advance in the production of hot strip steel and in cold-rolled strip.

Close regulation of the mill drive is required and to give this, motors and control have been developed and installed. Micrometric adjustment of the rolls has been obtained through motors and control specially designed for the purpose. The reeling of the strip steel has been accomplished automatically by mechanical tools, electrically driven and controlled. This accomplishment marks a definite advance in the production of perfect strip steel.

Steady improvement in detail of motors and control for such service is shown in the appartus installed, and this is marked rather than any positively new product of our industry.

Throughout the term, your committee has kept in touch with the proceedings and personnel of the Association of Iron and Steel Electrical Engineers. It has been the committee's purpose to help the Association as it might, and its Proceedings are referred again to the Institute as the most complete record available of electrical developments in the iron and steel industry.

In conclusion, your committee commends the plan of keeping continually in touch with the Association of Iron and Steel Electrical Engineers, giving it service wherever possible and bringing to the Institute its reports and findings, with suitable recognition. Your committee just concluding its services takes this means of acknowledging and expressing appreciation of the assistance rendered by these reports for the current term, as well as by the constant contact with representatives of the Association.

A. G. PIERCE, Chairman.

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*APPLICATION TO IRON AND STEEL PRODUCTION:
A. G. Pierce, Chairman,
A. C. Bunker, S. L. Henderson, F. O. Schnure,
F. B. Crosby, O. Needham, J. W. Speer,
A. C. Cummins, A. G. Place, G. E. Stoltz,
M. M. Fowler, T. S. Towle,

Presented at the Summer Convention of the A. I. E. E., Denver, Colo., June 25-29, 1928. Printed complete herein.

*Reprinted from the Journal of The American Institute of Electrical Engineers.

A. I. & S. E. E. JUNIOR DIVISION

(Devoted to practical problems of electrical department employees in the Iron and Steel Industry)

Factory Testing of Electrical Apparatus

PART 2

The information and data contained in this article was taken from the Westinghouse Electric & Manufacturing Company's Testing manual and if interpreted properly, will be of material assistance to the electrical maintenance department employees. This article is part 2 which began in the November issue of the Iron & Steel Engineer.

ADJUSTMENT OF MECHANICAL PARTS

Seasoning of Commutator

A commutator to be in good operating condition must run true and have a smooth polished surface free from high bars, high mica, or any other unevenness. It must also be capable of holding this condition indefinitely unless injured by excessive heating or sparking due to abnormal operating conditions.

In order that a commutator may meet the above conditions, it must be subjected to a seasoning process. This process consists in alternately heating and tightening the commutator until all volatile substances in the mica bond have been driven off and the bars themselves have become so seated that no more "give" can be obtained. In the smaller commutators, this can readily be accomplished in suitable ovens during the building process, but it has been found impossible to obtain a permanent set by this method when applied to the larger commutators. In such cases it is essential that the seasoning be carried on while the commutator is being revolved at approximately its rated speed so that all the forces existing under normal operating conditions will be effective during the seasoning process. Two methods are available for accomplishing this, the mechanical and the electrical.

In the mechanical method a leather belt lined with hard-wood blocks is placed over the commutator. One end is rigidly fastened to the floor or other support, the other is attached to a suitable linkage for adjusting the tension to that desired. Arrangement is also made for applying heat to the inside of the spider by suitable gas burners. The commutator is then run at approximately normal speed, heat being furnished by both of the above methods. Every few hours an attempt is made to take up on the commutator "V" ring bolts. A special slip wrench that does not permit an excessive strain to be imposed is used for this purpose. This process is continued until there is no longer any give in the bolts.

In the electrical process, the necessary heating effect is obtained by short circuiting the armature and so exciting the field that as much current as possible will flow through the windings without injurious sparking at the commutator. The excitation necessary will usually be found very small and it will be necessary to use high resistances in series with the field circuit to keep the current down. In some commutating pole machines, the commutating winding may be left in series with the armature on short circuit. This will permit a much higher current to circulate before the point of injurious sparking is reached. Care must be taken, however, that the brushes are on the neutral position (as mentioned under the heading, "The Position of Brushes" before running under this condition; otherwise, the machine will build up as a series generator and current sufficient to damage it may be generated. To avoid this, a circuit breaker should be wired in the circuit in series with armature and commutating poles. With this connection, the separate excitation of the shunt field may not be required, the current being controlled by shifting the brushes away from neutral.

The tension on the brushes should be adjusted to as high a value as possible so that their friction will increase the heating effect. A spare set of carbons must be used for this test as the rough commutator and excessive sparking that usually takes place would be liable to render the regular set unfit for future use.

In order that any defects may be certain to develop, all commutators must be run at normal operating speed during the seasoning process. If the bars show a tendency to rise, shut down and tighten the "V" rings while the machine is still hot. It may be necessary to repeat the heating process several times before the bars are finally seated and no more "give" on the "V" rings is obtained. After it is found that the bars are seated, the commutator should be turned or ground until it is in good condition. A good polish may be obtained by running several hours with hard brushes under heavy tension.

Fitting of Brush Holders and Brushes

All brush holders should be so adjusted that the brushes are set either radial, with, or against rotation as specified, to give the specified angle with the commutator. The holders should be set with the lower edges not more than ⅛ inch from the face of the commutator, and parallel with the commutator

segments. When there are several brushes on each arm, care must be taken that all the brush edges line up true and parallel as previously stated.

The relative spacing of the brush arms, as determined from the edges of the brushes, must be uniform around the commutator. This adjustment is made when assembling the machine, but may be disturbed by frequent handling. In all the larger machines, this point must be checked before starting any tests. The preferable method of doing this is to stretch a strip of paper tape around the commutator under the brushes allowing the ends to overlap to some extent. Care must be taken that it is smooth and parallel with the edge of the commutator at all points. A fine clear mark is made with a sharp pencil on the tape exactly at the toe of the brush on each arm resting on the tape. Some marks of identification should be made so that after removing the tape from the machine, the arms corresponding to the marks may be readily identified. On removal, the space between the marks is measured. This should be the same in each case; if not, it is at once evident which arms are at fault and in what direction to move them to make the spacing correct. After readjusting the arms at fault, the tape should be replaced on the commutator with the blank side up and the spacing rechecked. No case must be allowed to pass where the difference in spacing is more than 1/32 of an inch.

The brush holder springs must be so adjusted that the pressure on all brushes is uniform. The degree of tension varies to some extent, depending on the size and speed of the machine and the service to which it is subject. Brushes running on slip rings will maintain good contact with one and one-half pounds pressure per square inch; those running on railway motor commutators need from four to five pounds. Two to two and one-half pounds per square inch is a fair value in the case of the average machine. In general, the tension should be as light as possible and yet maintain proper contact with the commutator at all times. Whenever any doubt arises as to the correct pressure, the engineer in charge must be consulted. The pressure required must be obtained while the lever of the control spring is in either the lowest or next to the lowest notch.

The brushes must fit their holders snugly but must slide freely at all points. In the case of reversible motors, the play of the brushes in their holders must be as small as possible yet avoiding any possibility of binding.

Grinding of Brushes

All brushes must be so ground that the entire face of the brush is in contact with the commutator. Coarse sandpaper may be used for the roughing off, and fine sandpaper for the finishing. The paper should be gripped by the edges and held firmly against the surface of the commutator during the grinding; special care being taken that the edges of the brushes are not rounded off. On the finishing strokes, the grinding should only be done in the direction of rotation, the brush being lifted for the return stroke. If this operation is carefully performed, the brushes should polish up to a perfect surface after a few hours running. However, it will frequently be found necessary to touch up some of them. In some cases, it is necessary to run certain brushes for several hours under heavy tension to obtain the proper contact.

The Position of Brushes

For every direct-current machine or synchronous converter, a position of the brushes may be found, such that the voltage under the brush will be minimum. This is called the neutral position. For machines without commutating poles, this position shifts with the load and the brushes should be shifted accordingly, in order to obtain the very best condition for operation. However, as this is not practical in most cases, the brushes are set, as noted later, in the best average position for the case in hand. All such positions are referred to as being so many bars ahead or back of no load neutral; the no load neutral position always being the point of reference. In the case of properly compensated commutating pole machines, the neutral does not shift with the load; the effect of the commutating pole being to neutralize the naural tendency to shift. In such cases the brushes should be left on the no load neutral position under all conditions of load. It is standard practice, with most companies, to dowel the rocker arm carrying the brush holders of such machines to the frame so that no shifting can take place after the brushes have once been properly located. On large machines, where moving the machine may shift the rocker arm, this dowelling must be done before the machine is allowed to leave the test floor.

The Running Position of Brushes

The running position of the brushes of noncommutating pole machines that are to be operated in one direction of rotation only, is ahead of the no load neutral for generators and behind for motors. This is known as lead or lag. This position is determined by giving the brushes as much lead as possible to obtain sparkless commutation at no load, but the brushes must not be moved further than the full load neutral determined by setting the brushes at the points of minimum voltage between commutator bars, as found by the low reading voltmeter with full load on the machine. The number of bars lead or lag must always be noted.

The rocker arm position, having been determined, as above, must be clearly marked with a chisel; this being the permanent location of the brushes.

The running position of the brushes of commutating pole machines, in all cases, and of non-commutating pole machines for reversible service, is the no load neutral position, as found by the methods previously described. The rocker arm for this class of apparatus is permanently located with respect to the frame of the machine by means of a dowel pin so that it is impossible to shift the brushes from the above position.

DEFINITION AND METHODS OF DETERMINING NEUTRAL

The e.m.f. generated in an armature coil is a minimum when it is passing a line approximately midway between two adjacent main poles but, due to the throw of the coil, the corresponding commutator bars are opposite their centers and the brushes should be set in this position before proceeding with the more accurate determination of the true neutral

position. There are many methods in use for this purpose. Those chiefly used are as follows:

(1) The "Minimum Drop" method.
(2) The "Kick Neutral" method.
(3) The "Running Neutral" method.
(4) The "Reverse Rotation" method.

The Minimum Drop Method for Determining Neutral

In the "Minimum Drop" method, the machine is run at no load either as a motor or generator under approximately normal voltage. Voltmeter points, connected to a low reading voltmeter and held on adjacent bars, are moved along the surface of the commutator until the position of minimum deflection is found. In making this test, it is advisable to use an instrument having ½-1½-15 volt scales, using the high scale first and changing to the lower ones when it is certain that the deflection will be within their respective ranges. This method, as compared with others mentioned, is approximate only but is sufficiently accurate for locating the brushes on machines without commutating poles.

On commutating pole machines, it is essential that the true neutral position be determined with as high a degree of accuracy as possible. Otherwise, the compensating effect of the commutating poles will be shifted from its proper location relative to the coil being commutated. This will not only tend to produce poor commutation but will also effect other characteristics of the machine.

The Kick Neutral Method

The "Kick Neutral" method of determining the proper brush position is based on the fact that, on breaking the current flowing in the main field windings of the machine, voltages are induced by transformer action on the armature conductors. From a consideration of these voltages, it will be seen that those induced in the conductors located at equal distances to the right and left of the pole centers are equal in magnitude and opposite in direction. Keeping in mind the effect of adjacent poles, it is apparent that, if the terminals of a low reading voltmeter be connected to commutator bars correspond to conductors located midway between poles, no deflection will be obtained on breaking the field current. Brushes so set, that the center lines of their faces correspond with the center lines of the commutator bars between which such a result has been obtained, are evidently on neutral.

The procedure in finding this location is as follows: With the machine at stand still, all its brushes are raised, and one on each arm replaced by a special brush of the same cross section as the standard so that it fits the holder snugly. This special brush should be beveled to practically a knife edge parallel to its longer side and in the center of its face. It will, therefore, make a line contact with a commutator bar when in place. Leads from opposite brush arms are connected to a suitable voltmeter, preferably a ½-1½-15 volt scale so that the deflection may readily be adapted to the value obtained. The connection, however, must always be made to the higher scale first and only changed to the lower ones when it is certain that the deflection will be within their respective ranges. The shunt field circuit should be arranged for separate excitation and connected to any convenient source of direct-current power. For opening and closing the circuit, a knife switch, with an auxiliary quick break jaw, should be used, if possible, as the rate of breaking the circuit and, therefore, the inductive effect, will then be the same for each trial. The rocker ring is shifted until it is certain that the minimum deflection on opening or closing the circuit has been obtained. Where the commutator bars are evenly divisible by the number of poles, it is possible to be almost a bar off neutral by using the above method.

In such a case, the following method should be used: Select two mica segments under the center line of two brush faces on adjacent brush holders. Raise the brushes and take a kick reading, holding the voltmeter points first on the two commutator bars to the right and then to the left of these two mica segments. Rotate the commutator until these kick readings are equal and of opposite polarity. These segments will then be in the neutral position. The center line of the brush faces should then be placed over these mica segments.

The Running Neutral Method

It will be noted that the "Kick Neutral" method is applicable to both commutating and non-commutating pole machines, as the commutating poles have not been involved in its determination. As the commutating pole is the effective element in the commutation of commutating pole machines, it would seem logical that the location of brushes should be determined with reference to them and not to the main poles. It is evident, however, that if the spacing of each set of poles was correct, it would make no difference which were used as a basis of reference, but experience has shown that better results are obtained by using the commutating poles. Such a method had been developed, based on the principle that, with the brushes in the true neutral position, no active e.m.f. is generated by the commutating poles provided their magnetic circuits are symmetrical. This is termed the "Running Neutral" method, from the fact that during this test, the machine is running instead of standing still as in the "Kick Neutral" method.

Pointed brushes are inserted, one in each arm similar to those used in the "Kick Neutral" method except that the edges must be wide enough to cover the mica between segments and that they have a good even contact on the commutator. A reversing switch should be connected in the separately excited shunt field circuit and some arrangement made for exciting the commutating windings at from two to four per cent of their normal current. In connecting for this test, great care should be used to connect directly to the ends of the commutating pole windings, being sure none of the current flows through the series shunt, thus slightly exciting the series field and establishing a false neutral. Place a low reading voltmeter such as was suggested for the "Kick Neutral" method across opposite brush arms. Bring the machine up to approximately normal speed and by exciting the main field, for an instant only, in the direction contrary to normal, demagnetize it entirely; that is, until no deflection shows on the lowest scale of the voltmeter. Any deflection then obtained by exciting the commutating pole will be due to the commutating flux alone and not due to a combina-

tion of the two. First, excite the commutating winding with about two per cent of its normal current and shift the brushes until no deflection is obtained on the lowest scale of the voltmeter. Check the residual from time to time, keeping it at as low a value as possible by proper excitation of the shunt field. After determining the best location for the brushes at this excitation, raise the commutating pole current to about four per cent of normal and check results. If no difference is found, reverse the current in the commutating winding and try again, still checking the residual from time to time. In some cases higher current may be used but the leakage flux soon becomes large enough to destroy the symmetry of the abnormal field form and indefinite results will be obtained.

If the machine under test is for reversible service, or the direction of rotation is not known, the above is repeated for both directions of rotation and the brushes are set midway between the two positions indicated. These positions should be very close to each other. If the rotation of the machine is known, the brushes are set with the rotation in the required direction, only.

This method, if used carefully, gives very accurate results. It may be noted that the position of the brushes is at the peak of the commutating pole field form and as this peak is rather sharp, the effect of displacement will be very marked. Since the machine is running, errors, due to brush resistance or to a brush resting on mica, are entirely eliminated. It is preferable to the "Kick Neutral" method, in most cases, but, either method should give the same results. If any discrepancy is found, the spacing of the poles or brush arms is in error and should be investigated before proceeding further with the test.

The Reverse Rotation Method

Another method used for checking neutral is based on the fact that, when the brushes are in the neutral position, the speed as a motor will be the same in each direction of rotation; the voltage and field current being held constant. This method is preferred in the case of small commutating pole machines. In the conduct of this test, the machine is run as a motor at its highest rated speed and normal load in both directions of rotation. The speeds obtained in either direction under the same conditions must check to within two per cent; if the speeds are not within two per cent, the rocker arm must be shifted until the speeds are within this limit.

In the case of small commutating pole generators, it is often more convenient to set the brushes so that the machine will give the same voltage in both directions of rotation, the speed and field current remaining constant. It is evident that this is based on the same principle as that discussed in the paragraph above. In all tests for determining the correct position of the brushes by reversing the rotation of the machine under test, special care must be taken that the brushes fit their holders properly and that their faces have contact with the commutator at practically all points, irrespective of the direction of rotation.

Items of Interest

LUKENS STEEL COMPANY ANNOUNCES GAS CONTRACT WITH INTERNATIONAL COAL CARBONIZATION COMPANY

Mr. R. W. Wolcott, president of the Lukens Steel Company of Coatesville, has announced the closing of a contract with the International Coal Carbonization Company, a subsidiary of International Combustion Engineering Corporation of New York, which provides for the building of a low temperature coal carbonization plant adjacent to the Lukens Steel Company in Coatesville.

The cost of the new project will be between $2,000,000 and $3,000,000.

This plant will employ the K. S. G. process of low temperature carbonization, which has been in commercial use in Europe for over four years, and, will be practically a duplicate of the carbonization plant which International Coal Carbonization Company is now completing near New Brunswick, N. J., and which will be placed in operation within the next month.

Construction work will commence on the Coatesville installation the first of the year and the plant is expected to be in operation early in 1930.

This will be the first low temperature coal carbonization plant identified with the steel industry.

The new plant will sell gas to the Lukens Steel Company under long term contract to replace raw producer gas in their heat treating operations.

In addition to the gas derived from the new process other valuable constituents of the coal are recovered, consisting of high quality tar, light oils, anti-knock motor fuel and a high grade domestic fuel which will be marketed locally.

The initial installation will comprise six retorts and will be capable of carbonizing 500 tons of coal daily. The ultimate plant is designed for double this capacity.

Martin J. Conway, fuel engineer for the Lukens Steel Company and chairman of the combustion engineering division of the Association of Iron and Steel Electrical Engineers inspected the low temperature installation at Karnap, Germany, early this year and reported favorably on this new method of coal processing.

ROLLER SMITH ANNOUNCEMENT

Roller-Smith Company, 233 Broadway, New York, N. Y., announces a new and very novel instrument, the Type HEA-3 Polyphase Ammeter, which is illustrated and fully described in the enclosed Supplement No. 1 to Bulletin No. 450. The specific application of this instrument is for three phase alternating current circuits. With the Type HEA-3 ammeter it is possible to take readings

simultaneously in each of the phases of a three phase circuit. With this arrangement it is possible for the observer to see at a glance what the current is in each of the three phases and, thus, to determine instantly whether the phases are properly balanced. The long 7⅛" scale is an outstanding feature and the relatively small space occupied by the instrument as compared with the space occupied by three individual instruments is a feature of interest.

LUBRICANT—MACHINE TOOLS

Few realize the enormous pressures on machine tool and work centers during heavy machining operations. These pressures result from the weight of the work, the setting up on the centers and the expansion of the work due to rising temperature. For this reason a lubricant that will handle the average lubricating job is entirely inadequate for lubricating centers during heavy machining operations. The breaking down of work centers and the resulting delay and expense of recentering can in the majority of cases be traced to faulty lubrication. J. P. Flippen & Company, Oliver Building, Pittsburgh, Pa., has developed a lubricating compound put out under the trade name of Alloy-Lube which handles this center lubricating job with a marked degree of success. This compound is put out in two grades, Alloy-Lube (heavy) for work of five tons or more and Alloy-Lube (light) for work under five tons. For convenience this Alloy-Lube is put out in two-pound cans so each operator can have a can at his own machine tool.

NEW DELTA STAR BULLETIN

The Delta-Star Electric Company, Chicago, Ill., have issued a new bulletin No. 31-GA. This bulletin describes a new line of 600 volt collector rail support for cranes, ore bridges and industrial railroad service. It contains a table on Ratio of Steel Rail to Copper Resistance. Copy upon request.

WESTINGHOUSE STEEL MILL ENGINEERS PROMOTED

Changes involving the promotion of two steel mill engineers, both well known in the electrical and iron and steel industries, have been announced by the Westinghouse Electric and Manufacturing Company.

Mr. O. Needham, formerly section engineer in charge of steel mill engineering, has been appointed assistant superintendent, of the testing department, of the East Pittsburgh Works of the company. Mr. Wm. B. Shirk will replace Mr. Needham as section engineer in charge of steel mill engineering.

Mr. Needham enrolled as a student in the apprentice course of the Westinghouse Electric and Manufacturing Company in 1909, following his graduation from the Oklahoma Agricultural and Mechanical college, since which time his advance has been rapid. He comes to his new position well fitted, having had a broad experience in the engineering and works branches of the organization.

His connection with the general engineering department dates from 1919, during which time he has been engaged upon the calculation of motor sizes and the application of electricity to steel mills. Since 1926, he has been section engineer in charge of steel mill engineering. Mr. Needham has been influential in the engineering and placing in operation of many important steel mill electrification projects.

Mr. Needham is a member of the American Institute of Electrical Engineers, the Association of Iron and Steel Electrical Engineers, the Westing-

O. NEEDHAM

house Club, and the Pup's Foot Golf Club, and takes a very active interest in these organizations.

Mr. Shirk is admirably well fitted both by training and experience to assume the duties of his new position. He was graduated from Lehigh university

W. B. SHIRK

in 1920, with the degree of Electrical Engineer, but his connection with the steel industry dates as far back as 1914. He was secured by the Westinghouse Electric and Manufacturing Company in 1925, coming to that organization from the Bethlehem Steel Corporation where he held the position of assistant superintendent of electrical equipment.

Since becoming engaged with the Westinghouse organization, Mr. Shirk has played important parts

in numerous industrial electrification projects, including that of the American Sheet and Tin Plate Company of Gary Ind., in which six 2,500 Hp. motors and three 3,000 kilowatt motor-generator sets were involved.

Mr. Shirk is a member of the American Institute of Electrical Engineers, the Engineers Society of Western Pennsylvania, and the Association of Iron and Steel Electrical Engineers.

GEARS AND FORGINGS, INC., CLOSES LARGE BRIDGE CONTRACT

A great deal of popular interest has been displayed over the building of the Arlington Memorial bridge. This bridge will span the Potomac river at Washington and will be constructed along the latest bridge engineering designs. It is interesting to note that the Phoenix Bridge Company of Phoenixville, Pa., general contractors, have awarded the contract for furnishing the complete operating trunion and lock machinery for the bridge to Gears and Forgings, Inc. This bridge is a Straus double leaf Bascule draw span and incorporates the most modern designed machinery of this type requiring the highest degree of accuracy and workmanship throughout.

All the operations of the bridge are electrically controlled and operated. Each leaf is driven by means of two motors through enclosed types of herringbone reducing and equalizing double reduction gear units. The lock mechanisms are driven through enclosed type worm gear reductions. All gears throughout the construction have cut teeth including the main operating racks.

In addition to this bridge operating machinery Gears and Forgings, Inc., now have in process the complete operating machinery for two Double Leaf Bascule bridges of the Waddell Hardesty type. These contracts were awarded them by the Vincennes Bridge Company of Vincennes, Indiana. The two latter bridges will be installed at Wilmington, N. C., one over the Northeast River and the other over the Cape Fear River.

It is interesting to note that Gears & Forgings have recently erected a substantial addition ot their forge division to take care of additional work.

NEW I-T-E BULLETIN

The I-T-E Circuit Breaker Company, has just published a new bulletin that will be of unusual interest to every electrical engineer and to all industrial users of electricity as well as to those who are in any way concerned with the purchase of electrical equipment.

This bulletin, No. 220, covers an entirely new type of electrical protective equipment, the new U-RE-Lite all-steel distribution groups.

Electrical engineers have always desired to give their power and lighting circuits automatic protection and assure greater safety for operators. U-RE-LITE all-steel distribution centers with all "live" parts safely encased in steel accomplish this result.

The new bulletin gives you full particulars on this new I-T-E- line.

Copies of bulletin No. 220, will be forwarded to all interested parties on request.

MECHANICALLY OPERATED BRAKE

A new brake arranged for lever operation is being built by the Electric Controller & Manufacturing Company of Cleveland, O. This brake, known as the mechanically-operated, Type WB Brake, is of the shoe type and is intended for the bridge drives of electric traveling cranes, lifting bridges, electric hoists and other applications requiring foot-operated or hand-lever operated brakes.

This new brake is a modification of the E. C. & M. Type WB electrically-operated brake; practically all wearing parts of the new mechanically-operated brake are interchangeable with parts of the electrically-operated brake.

The tendency toward the use of anti-friction bearings on cranes and other machinery has resulted in an increased amount of work to be performed by the brake. A crane equipped with anti-friction bearings will drift along with practically undiminished speed when the controller is shut off, with the result that the brake must stop the crane unaided by bearing friction. This has necessitated improved brake design with increased wearing qualities of friction linings. The type WB brake is equipped with unusually thick molded asbestos brake shoes requiring renewal only after very long periods of service.

NEW DEPARTMENT OF COMMERCE STANDARD BOUNDARY AND OBSTRUCTION LIGHT

The Holophane Company, 342 Madison avenue, New York City, announces the New Department of Commerce Standard Boundary and Obstruction Lights.

These are special screw type globes with refracting prisms on the inside of the globe. The candlepower of the lamp is increased in all upward directions. No. 02203 is the small size for lamps from 15 to 50 watts. No. 02323 is the large size for 100 and 150 multiple lamps and 600-1,000 lumen series lamps.

Both globes are made of crystal, red, green and amber glass. An engineering folder describing these globes and giving photometric curves will be sent to those interested.

A NEW FARRELL BIRMINGHAM CO. BOOKLET

The Farrel-Birmingham Company have just published a new booklet describing the rolling mill units and giving charts containing horsepower capacities, general data on Sykes gears and illustrations showing their application.

The curves shown in the booklet are very interesting.

Write Farrell Birmingham Company, 344 Vulcan Street, Buffalo, N. Y., for your copy.

ANNOUNCEMENT

LeCourtenay Company of Newark, New Jersey, builders of single and Multi-Stage Centrifugal Pumps for all classes of service, has appointed J. P. Flippen, 503 Oliver Building, Pittsburgh, Pennsylvania, their Sales Manager for the Pittsburgh district.

THE SAFETY TROPHY FOR 1929

The Carnegie Steel Company originated the idea of putting industrial safety on a competitive basis and each year puts into competition among its plants, a safety trophy designed and executed by one of the foremost silversmiths of the country, and the composition usually symbolic of the industry.

The trophy for 1929 as portrayed above is the eighth that has been presented and is an actual Bessemer Converter in miniature, perfect in every detail, and fashioned after a converter at one of the principal plants of the company.

The converter, supports and accessories of sterling silver, rests on a bronze plinth oblong in form, 34 by 25 inches, bearing silver shields designed to carry the names of the monthly winners. The illustration above shows a side view of the converter, that the figures of the men might better be viewed. These figures adorn the front and rear of the composition and are bronze statuettes of two of the master steel workers, one at the Homestead plant and the other at New Castle, Pennsylvania.

ELECTRO DYNAMIC

"CLIP-WELD"

BALL BEARING INDUCTION MOTORS

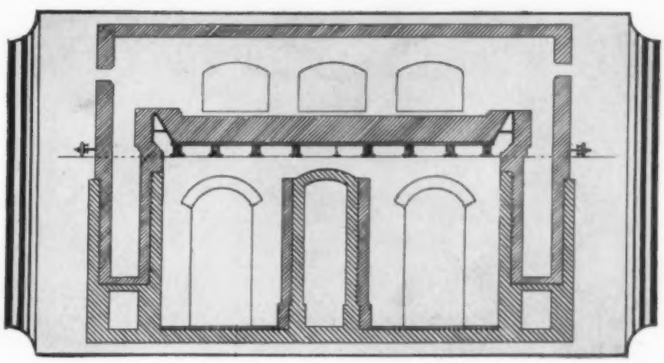
Manufacturers of Ball Bearing Motors Since 1904

ELECTRO DYNAMIC CO.

BAYONNE, N. J.

Quality for Half a Century

More Effective Heating



Reversing End Furnace

1 Cleanliness of operation
Healthy working conditions
Reduced plant maintenance
Decreased accidents

2 Fuel Savings
More than 25% in fuel heat units
As high as 75% in fuel cost per ton of finished steel

✓3 More effective heating
Reduced furnace losses
Reduced material losses
Increased output

4 Numerous installations
Many plants operating successfully over a period of years

5 Unified responsibility
Pulverizing equipment
Transporting equipment
Feeding & burning equipment
All manufactured by one organization

PULVERIZED coal permits of the widest range in flame conditions assuring more effective heating of industrial furnaces.

Increased furnace capacity, reduced furnace losses and a more uniform product result.

Savings as high as 75% in fuel cost and more than 25% in heat units have been secured over furnaces fired with other fuels.

Knowledge that comes of years of experience is behind industrial furnace recommendations of this company.

RESULTS

Ingots

Heating ingots in sand hearth type furnace with pulverized coal, 4,510,800 B. t. u. per ton of finished product.

Pile Heating

Heating wrought iron piles in sand hearth type furnaces with pulverized coal, 5,829,500 B. t. u. per ton of finished skelp.

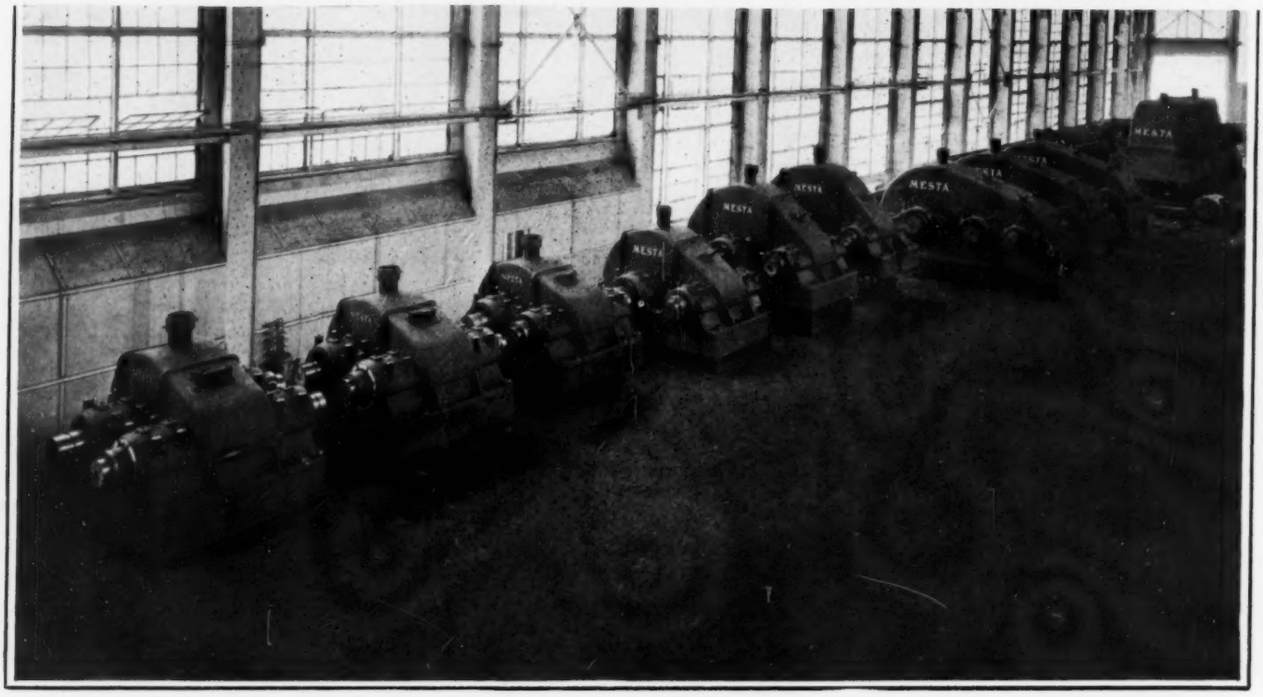
Puddling

Hand puddling of wrought iron with pulverized coal shows fuel consumption of 25,150,000 B. t. u. per ton of muck bar produced.

COMBUSTION ENGINEERING CORPORATION
International Combustion Building 200 Madison Avenue, New York
A Subsidiary of
INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

COMBUSTION ENGINEERING

10 more Mesta Gear Drives



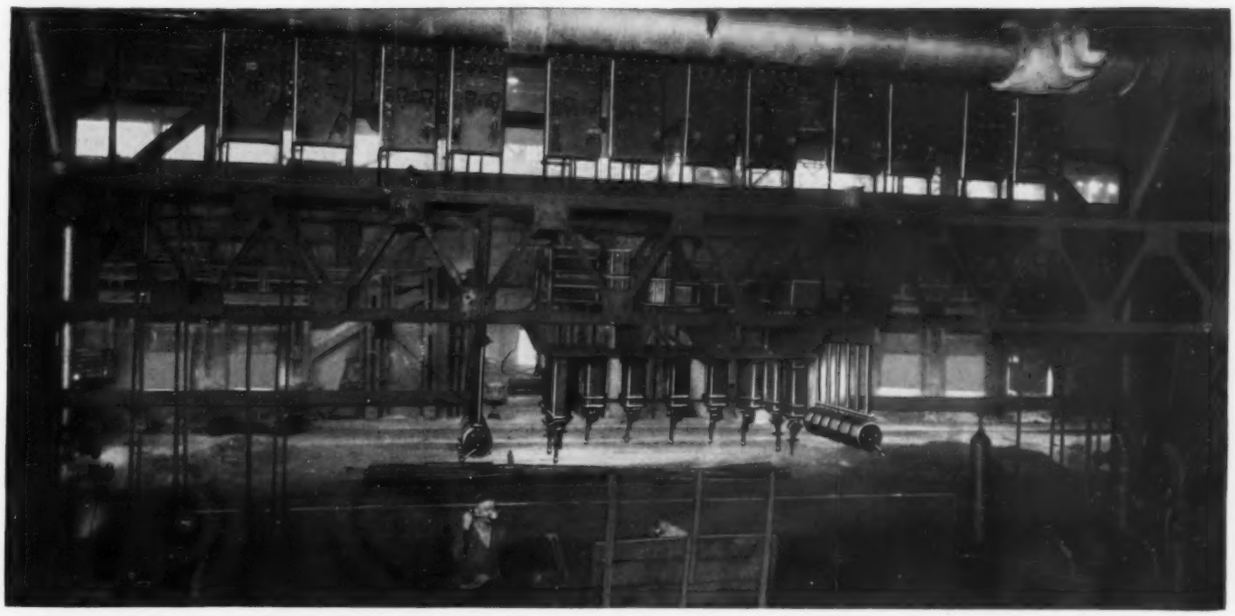
Write for a copy of Bulletin "B" which describes and illustrates Mesta Gear Drives and the processes by which they are manufactured.

The above illustration shows ten Mesta Gear Drives ranging from 900 H.P. to 3000 H.P. recently completed for a leading steel plant.

We are equipped to furnish either planed or hobbed gears up to the largest sizes.

Mesta Machine Company
Pittsburgh, Penna.

Mesta

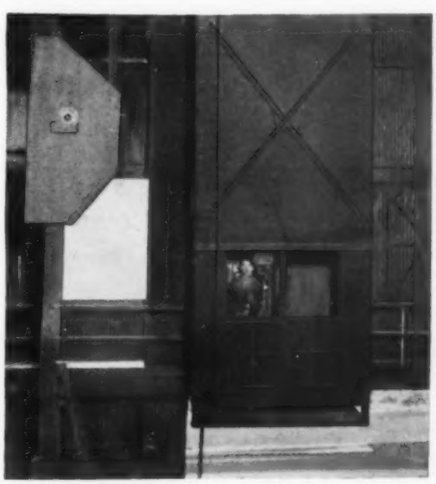


C-H *ITL Control keeps an eye on tonnage*

THE right amount of power for all loads—accurate manipulation of equipment—protection to motors—these essentials of "bogey" tonnage are assured by C-H *ITL* Control.

Motors are driven to their safe limit but never to dangerous excess—for C-H *ITL* cuts the motor off the line under any condition which might burn it out. These common causes of lost tonnage are thus avoided.

And because C-H *ITL* Control provides plenty of power for speedy handling of limit loads, yet prevents racing on light loads, the operator can manipulate his buggy, crane, etc. with time-saving precision—regardless of varying loads.



C-H ITL Control is particularly well fitted for such important and strenuous duty as crane service

There are still other ways in which C-H ITL Control guards your tonnage—all fully explained in the C-H booklet "Steel Must Never Stop." Shall we mail a copy?

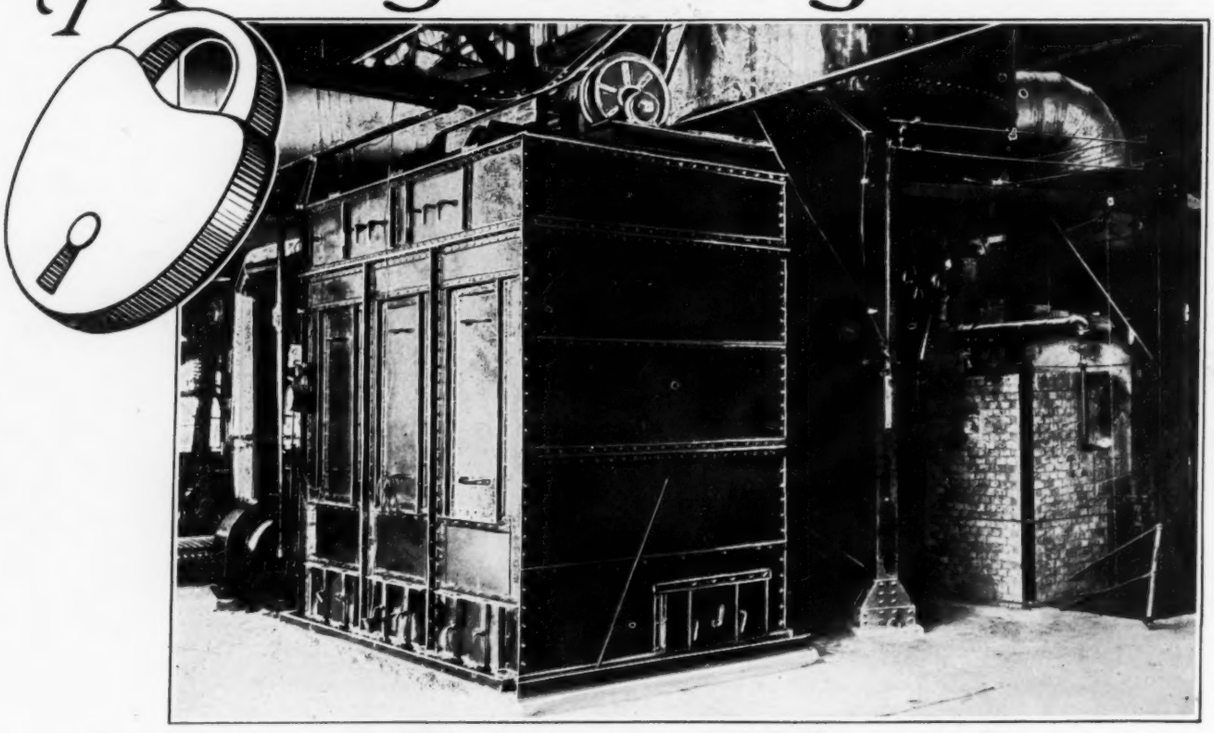
The CUTLER-HAMMER Mfg. Co.
Pioneer Manufacturers of Electric Control Apparatus
1269 St. Paul Avenue
MILWAUKEE, WISCONSIN

CUTLER HAMMER

The Control Equipment Good Electric Motors Deserve

(3061)

A Big Safeguard



Against Furnace Shutdown

By making certain that you will always have an ample supply of high temperature air, the **Blaw-Knox Regenerative Air Preheater** permanently removes one of the greatest single causes of furnace shutdown.

Assured Continuity of Operation Over Long Periods of Time Has Been Positively Proven

Let one of our engineers show you where a Blaw-Knox Preheater in your plant will render a handsome return on the investment. This Preheater is especially applicable to heating furnaces, steel and glass melting furnaces, soaking pits, etc.

BLAW-KNOX COMPANY

694 Farmers Bank Building, Pittsburgh, Pa.

New York Chicago Philadelphia Birmingham Detroit Cleveland Buffalo Baltimore

Export Division

Milliken Bros.-Blaw Knox Corp., Canadian Pacific Bldg., New York.

TRADE MARK BLAW-KNOX REG. U.S. PAT. OFF.

BLAW-KNOX

The sign of success

G R O W T H

WHILE the long experience we have had in the carbon industry is significant to the users of carbon products, it is not the only guide for them to follow. History lends prestige to an institution, and age is an asset. But there are many old companies that are no larger than they were when they started—they did not grow.

Growth is an evidence of success. We have grown steadily since the pioneering days of the carbon industry, and we are still growing. Our growth has been due to the ability to supply quality products, to meet modern requirements, and to use our experience in giving our customers an ever higher type of service.

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Unit of Union Carbide UCC *and Carbon Corporation*

Carbon Sales Division

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Branch Offices and Factories

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AN OUTSTANDING

ACHIEVEMENT

250 lubricants developed to meet 250 industrial needs!

SCARCELY an industry in the United States that has not felt the effect of the developments of the Keystone Lubricating Company. Scarcely an industry that has not cut lubrication costs—and repair costs—by the use of Keystone scientific lubricants and Keystone methods of *applying* lubricants.

For the Keystone Lubricating Company has built its reputation not alone by making the highest possible *grade* of lubricants—but by constantly developing *new kinds* of lubricants to meet new industrial needs and standards.

And today the Keystone Lubricating Company's research laboratories have 250 lubricants to their credit. Scientifically correct lubricants, all of them. And each especially designed to perform its specific lubricating task particularly well.

These lubricants are proving a decided economy in the many plants now using them—as countless enthusiastic letters in our files attest.

Let a Keystone lubrication expert look over your lubricating problems. Very likely he can point out definite ways in which you can save money and get more efficient lubrication besides.

KEYSTONE LUBRICATING COMPANY
ESTABLISHED 1884
21st, Clearfield and Lippincott Streets, Philadelphia, Pa.

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LUBRICANTS

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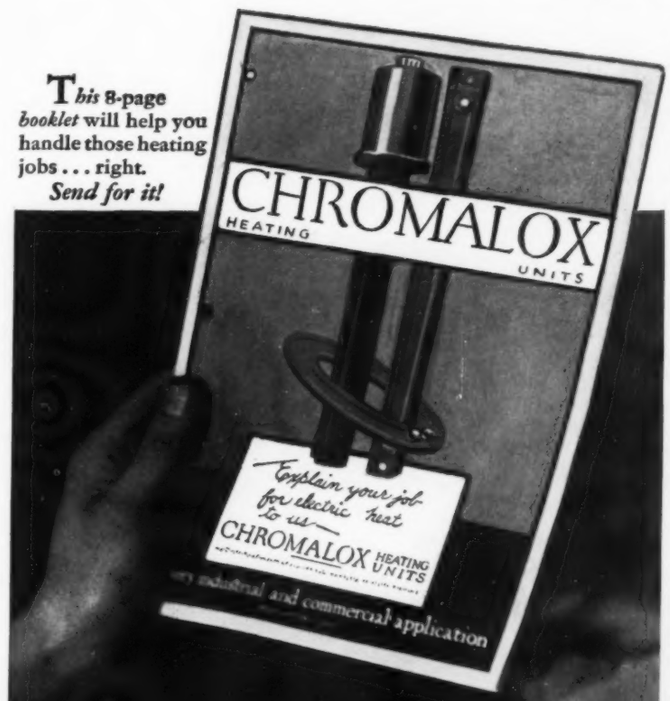
KEYSTONE SAFETY LUBRICATING SYSTEMS

★ WRITE FOR YOUR COPY
..*lick those* cold weather *Heating Jobs*



T*his* **8-page** ***booklet*** **will help you handle those heating jobs . . . right.** ***Send for it!***

You too, can save time and money—just as hundreds of companies are doing—by switching over to electric heat and putting Chromalox units to work on those heating jobs there in your plant. With electric heat you can do them quicker and better—without fire risks. And you can easily and accurately control the amount of heat you want.

For BIG Heating Jobs or Small Ones

Whether yours is a big job or a small one . . . . heating anything from tanks of fluids to compounds . . . . or melting anything from grease to metal . . . . or keeping pipe lines and equipment from freezing up . . . . or heating buildings varying from a watchman's shanty to a sizable warehouse or substation—the chances are that you can use stock heating units pictured and priced in this bulletin.

We Will Help You
put an end to your heating troubles

Before freezing weather starts giving you a lot of trouble, mail the coupon for your copy. And tell us all about what you want to heat so we can give you a quick and definite answer to your heating problems. There's no obligation.

Over 150,000 Chromalox Strip Heaters are heating cars on over 120 railways—the toughest kind of work! The Railway Utility Co., of Chicago is the sole distributor of Chromalox Strip Heaters for use in heating railroad and street cars in the United States and Canada. Sole Canadian Licensees: The Canadian Chromalox Co., Ltd., 251 Queen Street East, Toronto 2, Ontario.

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ELECTRIC HEATING UNITS

★ *. . . mail with your letterhead!*

Edwin L. Wiegand Co., 422 First Ave., Pittsburgh, Pa.

YES, without obligation, send me a copy of this Chromalox bulletin and any other data that will help me determine what heating units should be used for heating a _____

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Signed _____ *Position* _____

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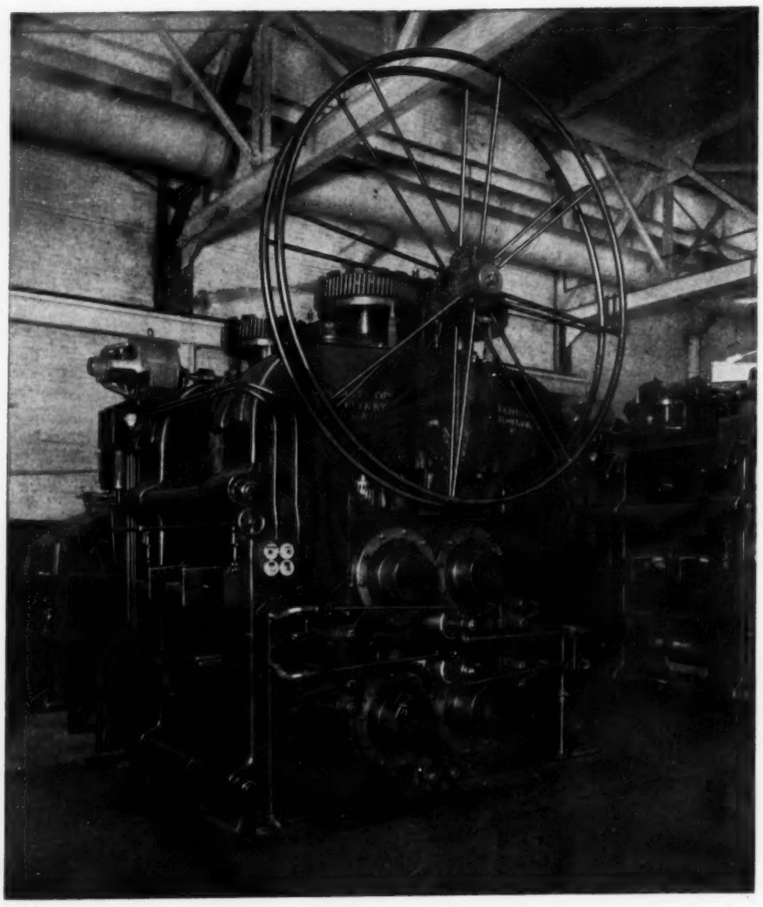

BLISS CLUSTER MILLS
Roller Bearing Equipped

Illustration shows an installation of Bliss Cluster Mills. These mills are built in capacities ranging from 4″ wide to 72″ wide, for hot or cold rolling. They are equipped with roller bearings. Full details on request.

E. W. BLISS CO. BROOKLYN, N.Y.
SALEM, OHIO.

If the Motor failed now

YOU hate to speculate what would happen if the motor failed when the furnace was half tilted. Just stop and think a moment . . . . lost production of course, but that's general . . . . carbons raised so you could not keep the metal hot . . . . cold metal to chip out with most of the lining attached . . . . a new lid . . . . and a furnace out of commission for days.

And a motor, cooking under the platform in fumes and slag dust, has every reason to fail. Ordinary motors will fail.

But Crocker-Wheeler Mill Type Motors are not ordinary motors. They are built for the job they have to do. Heavy steel frames . . . . Mica and Asbestos insulation . . . . minimum diameter armatures . . . . maximum diameter shafts . . . . huskier bearings . . . . dirt proof . . . . flame proof . . . . this is why Crocker-Wheeler motors do not fail.

You have too much invested in each furnace to dare to take a chance on other than the best motors. Send for Bulletin.

The Crocker-Wheeler Electric Mfg. Co.
Ampere, N. J.

Branch Offices:
Birmingham Boston Buffalo Chicago Cleveland Denver Detroit
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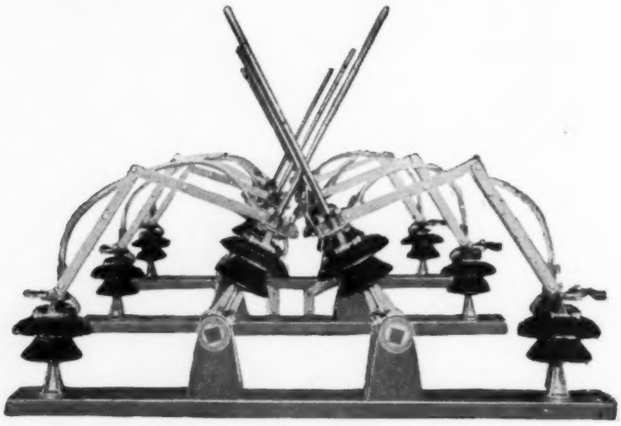
CROCKER-WHEELER

We still know that

ELPEC

Type R (DOUBLE TILTING) *Switches are necessary for:*

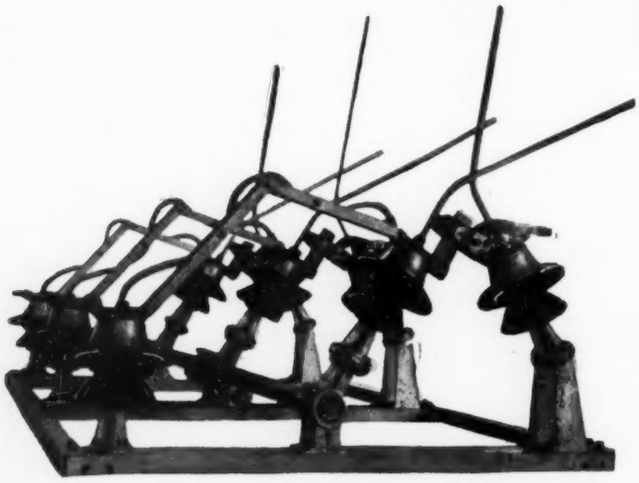
1. Quick break operation.
2. Maximum clearance between live parts.
3. Ability to break heavy loads.
4. Adaptability to clear heavy charging currents.



TYPE R

.....BUT.....

—if your system operation does not demand this super-switch



THEN USE

the new **Type S**

(*single tilt*) **Switches**

which incorporate many of the best features of the original Type R switch at a lower cost.

Check the following points of merit:

—the over insulation
—the full floating contact
—the uniform spring pressure on both sides of the contact shoe
—the interchangeability of insulator units
—and the current densities

for the good of the Service

ELPEC

ELECTRIC POWER EQUIPMENT CORPORATION

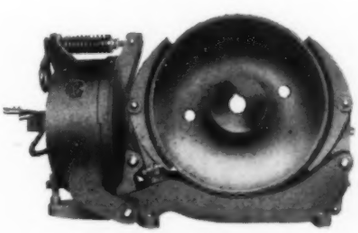
412-420 NORTH EIGHTEENTH ST. PHILADELPHIA, PA.

MECHANICALLY OPERATED TYPE WB BRAKES

ARE NOW IN PRODUCTION

FOR Bridge Drives on traveling cranes and many other applications requiring a lever operated brake of sturdy design, the new EC&M Type WB Brake is now available.

The extra thick moulded asbestos shoe linings contribute to exceptionally long shoe life. This is of particular importance on cranes equipped with anti-friction bearings where the service on the brakes is unusually severe.



Electrically Operated Type WB Brake

When Buying Cranes Specify EC&M Type WB Mechanically Operated Brakes For Bridge Drives And Type WB Electrically Operated Brakes For Hoist Motors.

Bulletin 1004–A, just off the press, gives complete data on WB Brakes.

THE ELECTRIC CONTROLLER & MFG. CO.

NEW YORK-50 CHURCH ST. CLEVELAND, OHIO PHILADELPHIA-WITHERSPOON BLDG.
CHICAGO-CONWAY BLDG. HOUSTON-1006 WASHINGTON AVE. PITTSBURGH-OLIVER BLDG.
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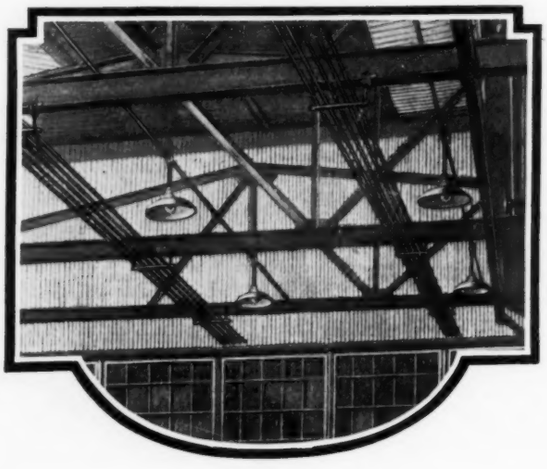
Flexible FIXTURE HANGERS

Type UNJC
Cushion Fixture Hanger



Type UNJ
Ball Fixture Hanger

Cord Clamp Cover for Obround Condulets, except Form 7 Series

Cushion Fixture Hanger for Obround Condulets, except Form 7 Series

Type AOC
Ball Fixture Hanger

Type ALC
Ball Fixture Hanger

Cushion Fixture Hangers are provided with a spring which absorbs any shocks due to vibration or from other causes. For use where there is extreme vibration.

Ball Fixture Hangers are arranged with a ball and socket joint which permits a free swing in any direction. For use where there is no extreme vibration.

Listed in Bulletin 2102

Type GS
Ball Fixture Hanger
For Condulets of the GS series. Absolutely watershedding.

Type ARB
Ball Fixture Hanger
For use on 4-inch outlet boxes already installed.

CROUSE-HINDS COMPANY

ESTABLISHED 1897

SYRACUSE, N. Y., U. S. A.

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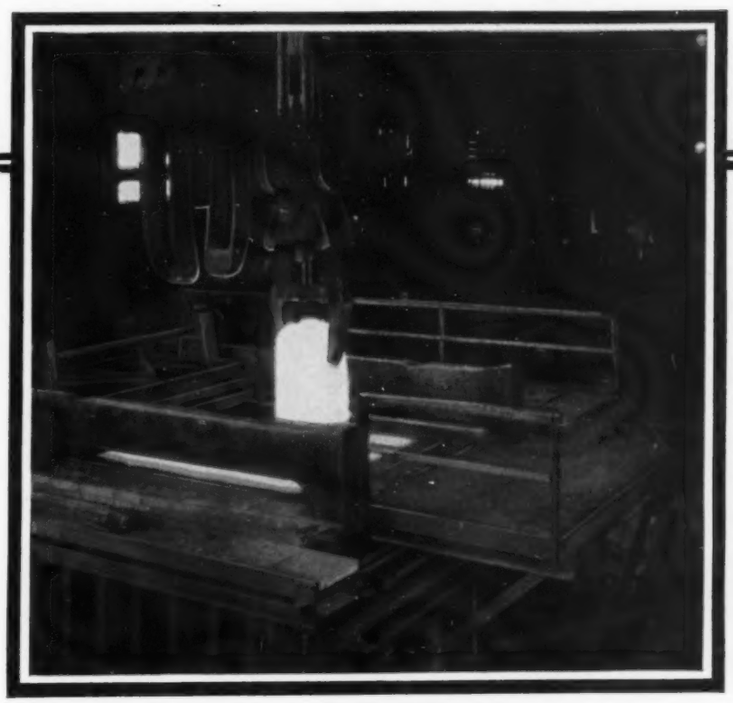
C-H 370



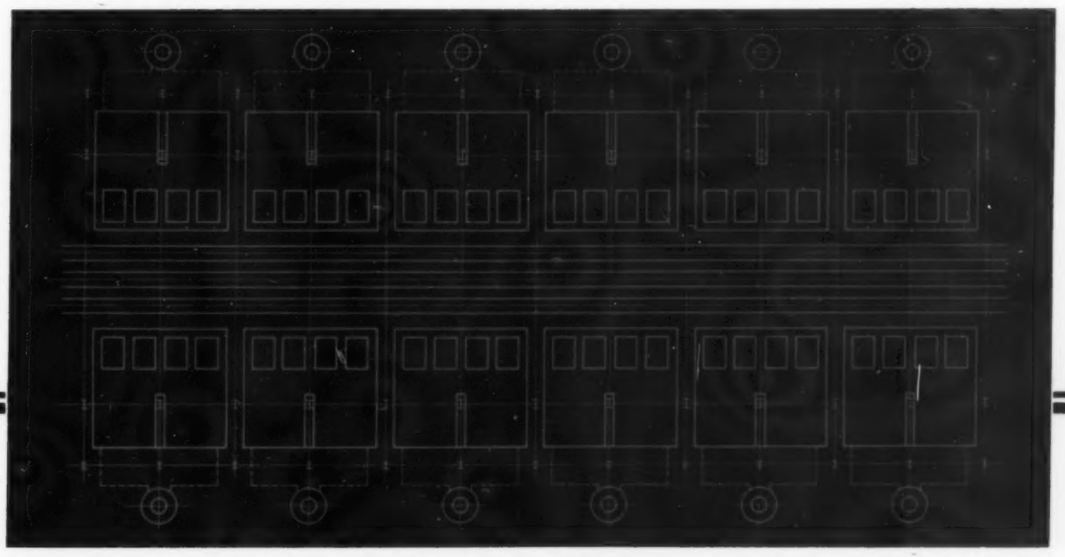
AFTER visiting one of the Chapman-Stein Recuperative Soaking Pit installations, a well known steel plant executive reported, "THAT IS THE TYPE OF PIT WE SHOULD INSTALL." He had observed the small floor space required, the greater ease of operation, the uniform ingot temperature and low scale loss. The operating records showed him a lower operating cost and lower installation cost.

Would you like more information on recuperative soaking pits? Write to

The Chapman-Stein Company

"Allied with The C. & G. Cooper Company"

Mount Vernon, Ohio



Plan showing space saving feature of Recuperative Soaking Pits and more accessible arrangements of tracks and crane ways.

Accuracy

YOU can't appreciate the superior qualities of a STACKPOLE Carbon Brush by merely looking at it. But put a set of STACKPOLES in one of your motors—as prescribed by our Engineers—and notice the pickup in your motive power.

From then on you will want STACKPOLES and nothing else—just as hundreds of other regular STACKPOLE users have done.

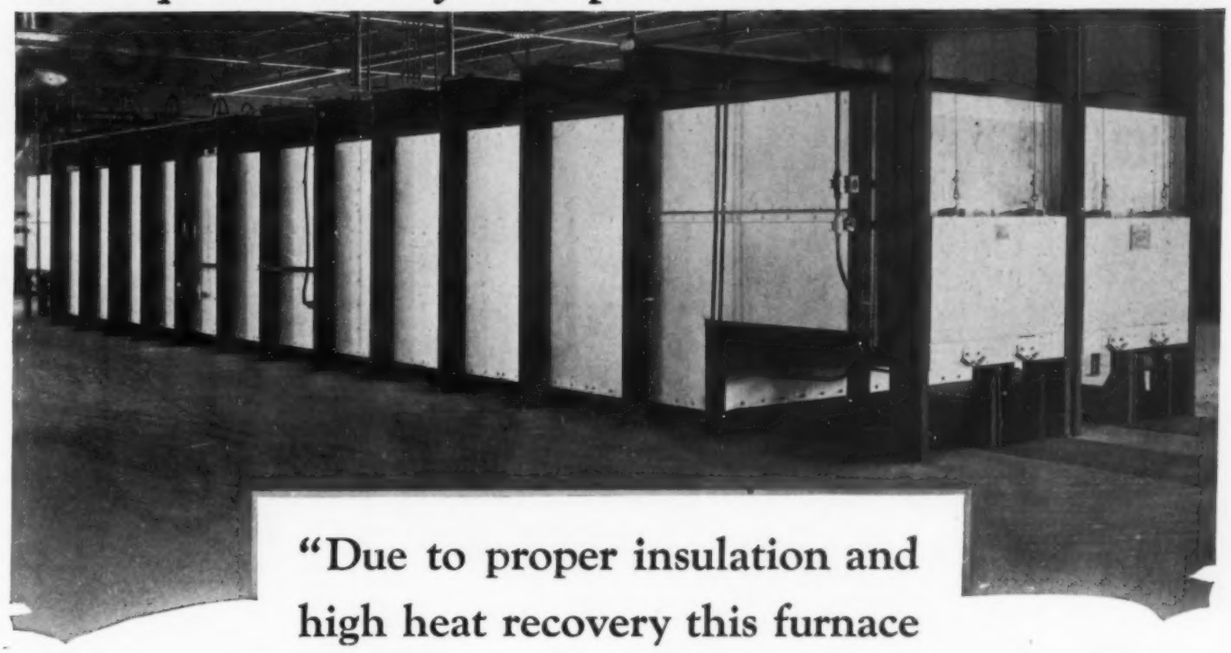
For STACKPOLE Brushes are a product of laboratory accuracy. Exacting proportions of carefully selected material are compounded to meet the individual requirements of each type of motor.

Write us about the type and service to which your motors are subjected. Our Engineers will be glad to recommend the scientifically correct type of STACKPOLE Carbon Brush to use.

STACKPOLE CARBON COMPANY
St. Marys, Penna.

Stackpole carbon brushes

1750 square feet of J-M Superex are used in this furnace



"Due to proper insulation and high heat recovery this furnace

Shows SAVINGS of more than 50%

over the ordinary batch type furnace"

THIS 360 KW T-grid electric carburizing furnace, manufactured by the Electric Furnace Company of Salem, Ohio, has a capacity for carburizing 3,000 lbs. of camshafts and miscellaneous parts per day. Full credit for its high record for economy is given by the makers to Johns-Manville Superex Insulation.

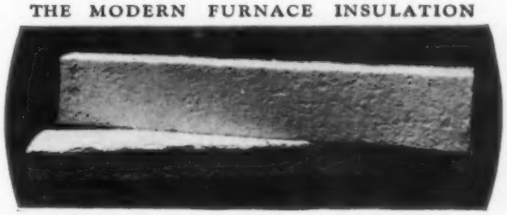
It is significant that many of the leading manufacturers of furnaces and other equipment, operating at high temperatures, use Superex almost exclusively.

Johns-Manville Superex is the most efficient and adaptable insulation for high temperature service. Composed of asbestos fibre and materials of high insulating value, bonded into strong, tough, homogeneous blocks that will not split or crack under heat, Superex retains its insulating efficiency throughout the life of the lining. It combines the ideal properties of good insulating value, high temperature resistance, mechanical strength, and moderate cost. Superex has the lowest thermal conductivity of any furnace insulation now on the market.

J-M Superex Blocks are of large size—6" x 36"—which makes it possible to set up furnace linings in much faster time and with proportionately lower labor costs than when the insulating material is furnished in small sizes only.

SUPEREX

THE MODERN FURNACE INSULATION



The services of our staff of furnace insulation engineers are freely placed at your disposal. *Address Johns-Manville Corporation, 292 Madison Avenue, New York City.*

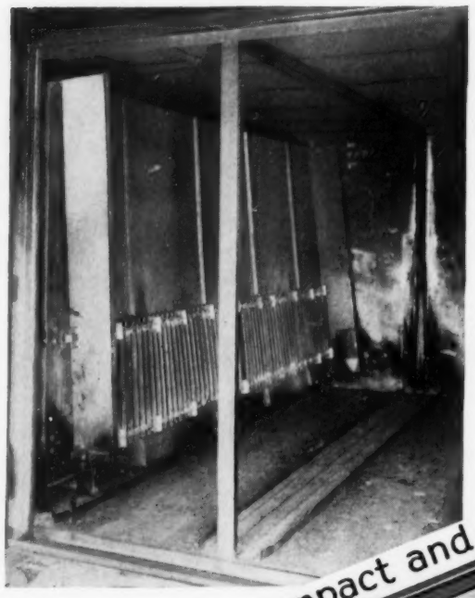
MASTER of ASBESTOS

Johns-Manville

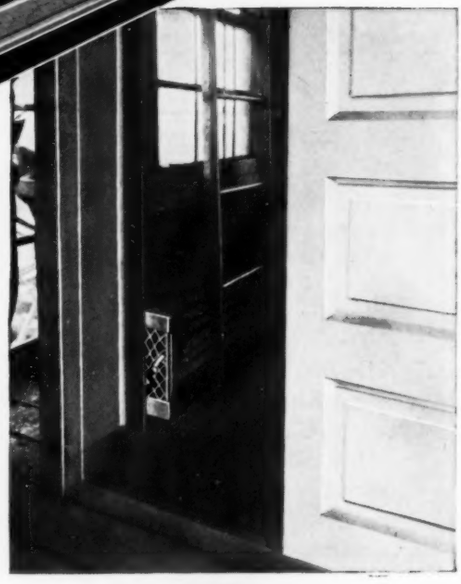
SUPEREX INSULATION BLOCKS

Generate heat *where* it's used

—without piping or fire hazard



C-H Space Heaters provide the most economical method of heating this oven—in the plant of a prominent lamp company



C-H Space Heaters provide the simplest way to heat isolated enclosures such as this coal bridge cab

FOR heating crane cabs, where no other heat will reach—for protecting water pipes in far corners of the plant—for applying heat at specific points in manufacturing processes—on these and many other applications C-H Space Heaters provide a simple, safe, and economical solution to heating problems.

Just two feet long, compact and slim, used singly, in pairs, or in groups, C-H Space Heaters can be installed anywhere—generate the desired quantity of heat where and only where needed.

Inexpensive—C-H Space Heaters cost only $2.00 each and somewhat less in lots of 10 and are carefully constructed for minimum current consumption.

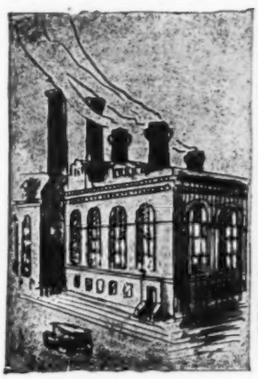
Full particulars—including numerous money-saving suggestions—are given in the "Dictionary of Uses". Write for your copy and order C-H Space Heaters from your jobber.

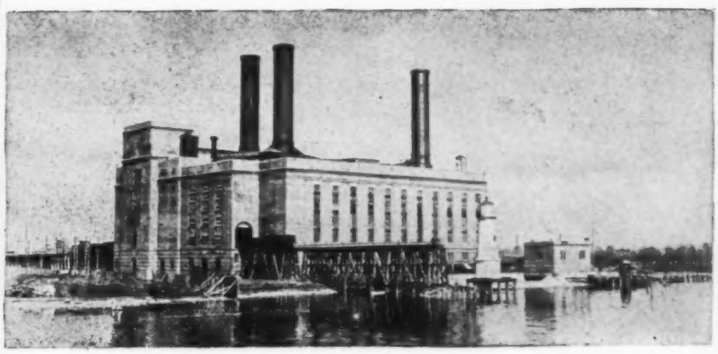
The CUTLER-HAMMER Mfg. Co.
Pioneer Manufacturers of Electrical Apparatus
1270 St. Paul Avenue
MILWAUKEE, WISCONSIN

The heating element of the C-H Space Heater is embedded in a highly efficient refractory material, which assures quick, economical heating, perfect insulation for the coil, and remarkable durability

CUTLER HAMMER

Space Heaters ~ Two Feet of Electrical Heat





The Men Who Know

Prefer FRANKLIN standard duty units

Type "I", Bus Supports are especially suited for industrial plant and Mill service. Due to the rugged construction and low cost, they are also desirable for standard Central Station work.

SIMPLE CONSTRUCTION. Knurled inserts are carefully cemented in recesses at each end of porcelain and cured in steam room.

HARDWARE is assembled with one bolt or stud. Base and lower half of clamp is Enameled malleable iron and upper half of clamp is Bronze.

RATING—7,500 to 37,000 volts. All styles of mounting.

RAILWAY AND INDUSTRIAL ENGINEERING CO. GREENSBURG, PA.

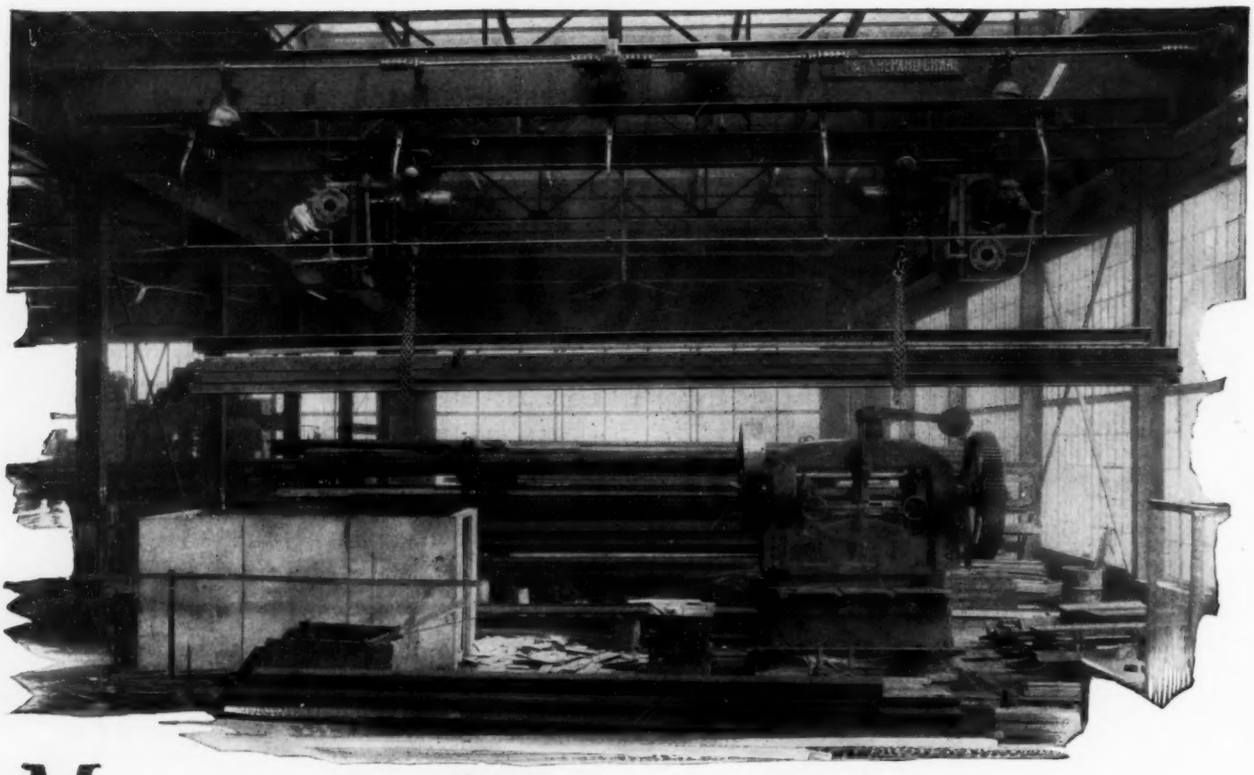
Offices in Boston, New York, Philadelphia, Pittsburgh, Charlotte, Cleveland, Chicago, Cincinnati, St. Louis, Denver.

See Section 3200 of the Latest R. & I. E. Catalog For—

Type "I," Series "L" Bus Support showing single pipe mounting and round conductor clamp.

Type "I," Series "A" is a heavy duty unit employing the insert construction as shown above.

-:- INDOOR BUS SUPPORTS -:-



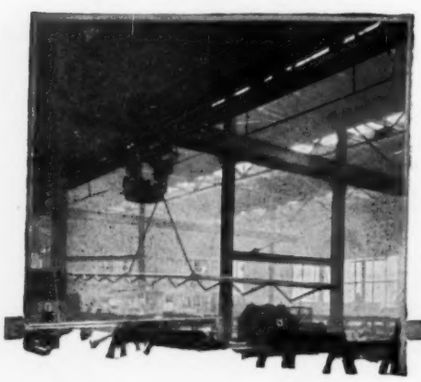
Maintaining *Maximum Production* with the "Aerial Railway"

Moving is the major part of making at the Walter Bates Steel Corp., Gary, Ind. Heavy unwieldy I-beams and expanded steel girders must be handled with speed and precision to maintain a uniform, profitable production flow.

Here Shepard's Aerial Railway of Industry plays an important part. It provides for rapid load-moving from one part of the plant to another, from crane bay to crane bay —without changing the load. One, two or more of the Shepard Monorail Hoists—to suit the type of load—operating on a Shepard Transfer Crane, pick up their load. Adjacent transfer cranes are latched together. The hoists carry the load from one to the other. No time lost in changing the load. Each hoist serves every square foot of floor space in every crane bay throughout the entire plant.

Planned load-moving is effecting striking economies throughout industry. Let a trained Shepard Engineer show you how Shepard Cranes or Hoists can be applied to cut your load handling costs.

Adjacent transfer cranes latch together, as shown below, when the Shepard Monorail Hoist carries its load from one crane bay to the next.



SHEPARD ELECTRIC CRANE & HOIST CO., 376 Schuyler Ave., Montour Falls, N.Y.
Branches in Principal Cities

SHEPARD
ELECTRIC CRANES & HOISTS

Member of Electric Hoist Manufacturers Assn Largest Manufacturer of Electric Hoists in America

POWER PLANTS

ONE MILLION K.W. is the ultimate capacity of the Central Station shown at the top of the page. The Laundry, illustrated below, operates a 70 h.p. boiler.

Both plants are equipped with fuel burning apparatus, designed, manufactured and installed by Combustion Engineering Corporation.

There is no sharp dividing line between the responsibilities of the stoker or burner manufacturer, the furnace builder and the boiler maker. Steam Generation is a combined process of heat liberation and heat absorption. The performance of individual elements is secondary to the performance of the combination —*as a unit.* The ultimate goal sought is to produce a dependable supply of steam at minimum cost.

The operation of the Laundry is dependent upon the performance of this 70 h.p. boiler, while thousands of New Yorkers rely upon the East River Station for light, power, transportation and the many material comforts of life which electricity has made available.

The engineering, research and manufacturing facilities of Combustion Engineering Corporation are available to American Industry in raising the standards of Fuel Burning and Steam Generation, throughout the entire range from 70 h.p. to 1,000,000 K.W.—*or beyond.*

A 70 h. p. boiler serves this laundry

COMBUSTION ENGINEERING CORPORATION

International Combustion Building, 200 Madison Ave., New York

A Subsidiary of

INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

NEW YORK EDISON COMPANY
Thomas E. Murray, Inc.
Designing Engineers

POWER PLANTS
From 70 H. P. to 1,000,000 KW. ult. ✓

BOILERS
From 70 to over 4,000 rated boiler H. P.

PULVERIZED FUEL
Complete systems with Mill capacities from 600 to 60,000 lbs. of coal per hour.

STOKERS
For capacities from 250 to 40,000 lbs. of coal per hour.

WATER COOLED FURNACES
From 90 sq. ft. to 4,132 sq. ft. of water wall surface.

AIR PREHEATERS
From 217 to 66,942 sq. ft. of heating surface.

COMBUSTION ENGINEERING

20-ton Westinghouse equipped industrial locomotive of high-speed acceleration.

SPEEDING UP STEEL PRODUCTION

75 Round Trips Per Hour from Soaking Pit to Rolls

THIS is not a "record" time but the normal every-day performance of this Westinghouse-equipped electric locomotive carrying ingots over 325 feet of level tangent track between the soaking pit and the rolls in a large Pennsylvania steel mill. Only 48 seconds for a complete cycle, including 4 seconds at each end for loading and unloading.

This remarkable performance is made possible by a starting speed acceleration of 2½ miles per hour per second per second.

The locomotive is driven by two 150-hp. forced ventilated motors equipped with roller bearings in the main journals.

Electro-pneumatic control is provided with safeguards of automatic braking in case of power failure, as well as the dead man's handle.

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania

Sales Offices in All Principal Cities of the United States and Foreign Countries

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Westinghouse

MARTINDALE MOTOR MAINTENANCE EQUIPMENT

Hullhorst

MOTOR-DRIVEN

Undercutters

For
Slotting
Commutators

Shipped on Approval

7 Different Types From Which to Make Selection—

5 of which will Cut both "U" and "V" Shaped Slots.

MARTINDALE ELECTRIC CO.

CLEVELAND, OHIO, U. S. A.

MARTINDALE ELECTRIC CO.,
1256 W. 4th St., Cleveland, Ohio, U. S. A.

Send me your No. 9 Catalog of 24 pages illustrating and describing Hullhorst Undercutters and other interesting and useful Commutator Slotting Equipment.

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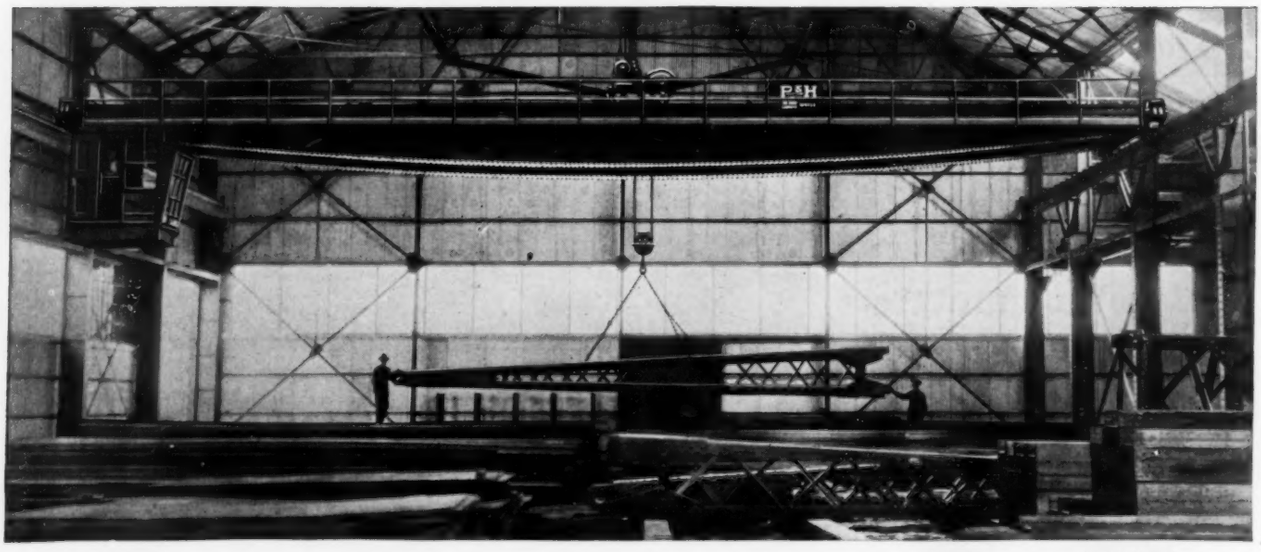
Street and No.....

City and State.....

By (name and title)..... 12/28

MARTINDALE MOTOR MAINTENANCE EQUIPMENT

Why.....



there are more P&H Cranes in Service than any other make

The Overhead Electric Traveling Crane is a vital artery of transportation in industry. It must, above all, be dependable — and business demands that it also show low cost per year of service. To provide these qualities, P & H builds into its Cranes only the finest materials and workmanship.

This is proved by the fact that the majority of the largest Crane users in the United States, who buy on *performance* and not on *price*, have standardized on P & H Cranes.

HARNISCHFEGER CORPORATION

Established in 1884
Crane and Hoist Division
3855 National Ave., Milwaukee, Wis.
Offices and Agents in All Principal Cities

A Few of the Larger P & H Crane Users	No.
American Brass Co., various plants	278
Allis Chalmers Mfg. Co., West Allis, Wis.	272
Bethlehem Steel Co., various plants	238
Baldwin Locomotive Works, Phila., Pa.	91
Ford Motor Co., Detroit, Mich.	73
International Harvester Co., Chicago, Ill.	69
American Brown Boveri Co., Camden, N. J.	65
Pennsylvania Railroad Co., various plants	45

CRANES P&H HOISTS

"3C" VARI-TIME MAGNETICS

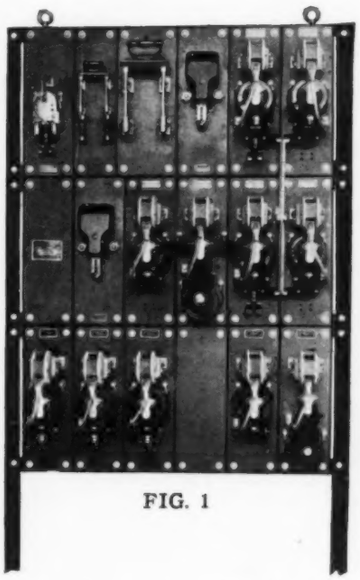


FIG. 1

Fig. 1 shows a "3C" Magnetic Controller which is now operating with a motor on a crane hoist. This Controller takes care of lowering overhauling loads at a safe speed.

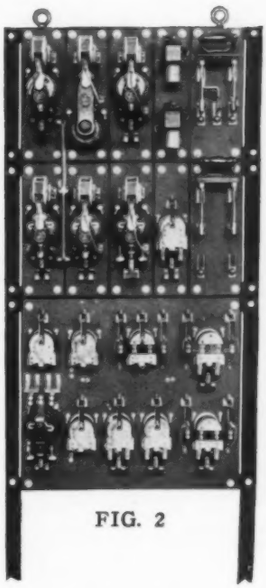


FIG. 2

Fig. 2 shows a "3C" Magnetic Controller, Non-Reversing, with special automatic features for operation of large sheet mill shears.

FIG. 4

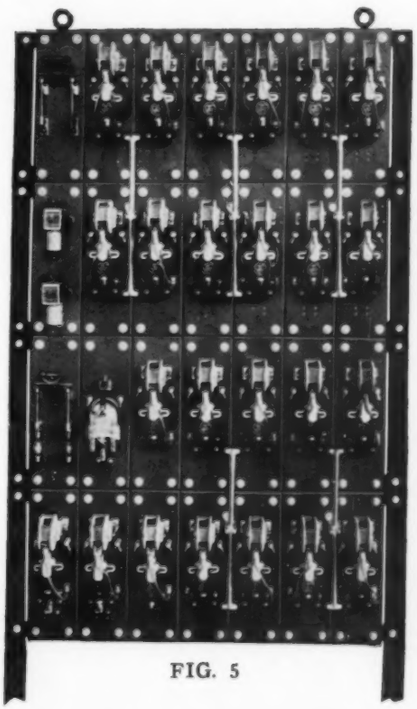


FIG. 5

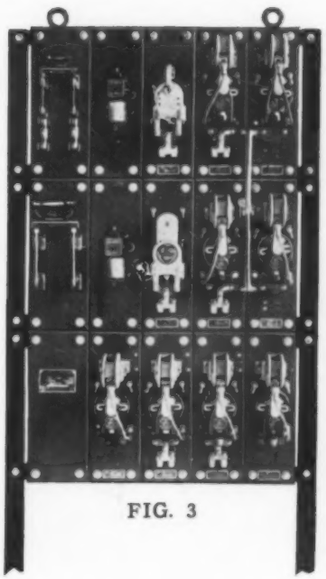


FIG. 3

Fig. 3 is the typical "3C" Magnetic Controller, Reversing, Plugging Type, similar to heavy duty mill table service.

Figures 4, 5 and 6 represent complete Control Equipment for selective operation of a group of motor operated open hearth doors. (Figures 4 and 6 shows front and rear views of Master.)

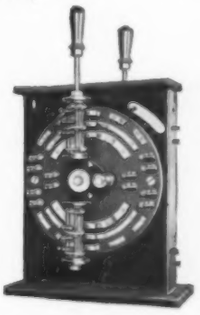


FIG. 6

THE CLARK CONTROLLER CO.

BIRMINGHAM CHICAGO CINCINNATI DETROIT LOS ANGELES NEW YORK 1146 EAST 152ND STREET CLEVELAND, O. PHILADELPHIA PITTSBURGH PORTLAND, ORE. SALT LAKE CITY SAN FRANCISCO SEATTLE

JEWELL

Progress Demands Efficient Instruments

Progress demands efficiency in electrical instruments as well as in industrial machinery for the instruments are often the means by which the machinery of industry is directed.

Jewell Instruments satisfy the requirements of modern progress in many ways. They are designed from the standpoint of efficient and lasting service and are constructed from the best of available materials. They are produced with the knowledge that their use will create satisfaction.

Part of the complete Jewell line is the intermediate size instrument represented by Pattern 25 illustrated. This instrument is furnished as either A.C. or D.C. in drawn steel cases 4¾ inches in diameter and 2⅜ inches deep. The scales are 3¼ inches long drawn on white bristol board. Direct current instruments have a D'Arsonval type movement of ample sensitivity for use as galvanometers or with thermo couples for high frequency work and the alternating current instruments contain a rugged repulsion type iron vane movement.

This instrument together with the complete Jewell line of instruments is described in the Jewell catalog No. 16. Write for a copy.

JEWELL

"28 Years Making Good Instruments"

Jewell Electrical Instrument Co.

1650 Walnut St., Chicago

1891 — 1928

MORGAN
Construction Co.

Worcester, Mass., U. S. A.

Designers and Builders of

Morgan Continuous Mills

for

Billets, Sheet Bars, Skelp, Merchant-Bars, Hot--Strip, Rods

also

Wire Drawing Machines
Producer-Gas Machines
Straightening Machines
Isley Furnace Control
Re-Heating Furnaces
Reducing Gear Units
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Our Engineering Department

is prepared to solve successfully your problems in design or arrangement of plant and equipment from open hearth to finished product.

1891 — 1928

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Bull Dog Safety Switches
Beaver Stocks and Dies
Hubbard Pierce Pole Line Specialties
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Tork Clocks
National Metal Molding Conduit and Fittings
Steel City Electric Products
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SIXTH AVE. & DIAMOND ST.

PITTSBURGH, PA.

Special transformers *but* .. at prices

in line with standard equipment

For instance: A special situation comes up in your plant. You require transformers built to your specifications. Stock equipment won't do.

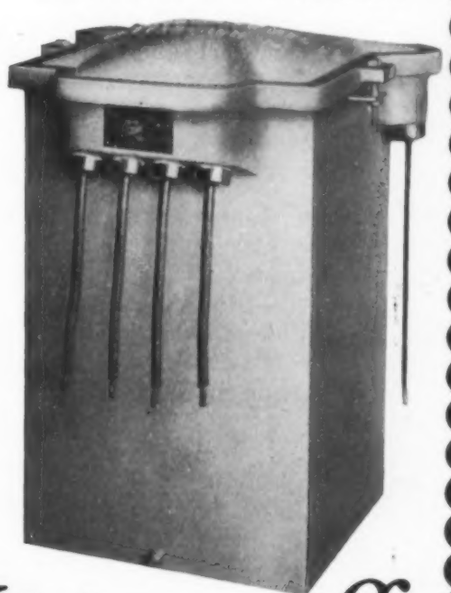
You want these transformers shipped within a reasonable time. Production—the work of men and machines—must not be delayed. Above all, this specially-built equipment must not cost a young fortune. The price must be in line with standard equipment.

It's on this basis, that we are building—and have been building for some years—hard-working transformers for dozens of companies. We'll be glad to work with you on standard or special equipment.

R. E. UPTEGRAFF MFG. CO.

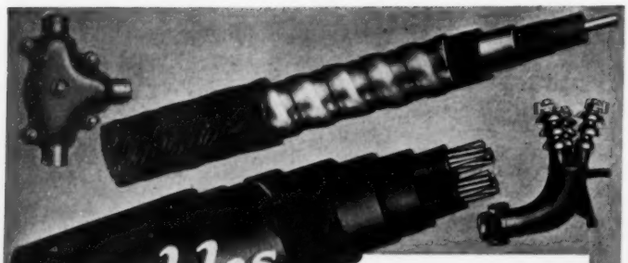
Sales Office

1414 Clark Bldg. Pittsburgh, Pa.



Uptegraff Transformers

Other Transformer Products: Potential - Distribution - Small Power - Testing - Boosting - Furnace - Auto - Motor Starting Auto - Reactance and Balance Coils.



Cables

armored with Steel – yet flexible as Lead

STANDARD makes two types of Armored Cables:

A Single-Interlocking-Steel-Tape-Armored Cable *(Spiraloc)* and a Double-Steel-Tape-Armored-Cable.

The two meet all requirements of ductless underground cable installation.

Both have an overlapping armor of steel tape which assures flexibility, durability, and dependability.

Installations of these cables mean real and lasting economy. In many cases, a 50% saving has resulted as compared with single runs of lead-covered cables in conduits.

To make your installations uniform and of utmost dependability, use STANDARD Joint Boxes, Junction Boxes, Terminals and other STANDARD accessories in connection with STANDARD Cables.

Standardize on STANDARD.

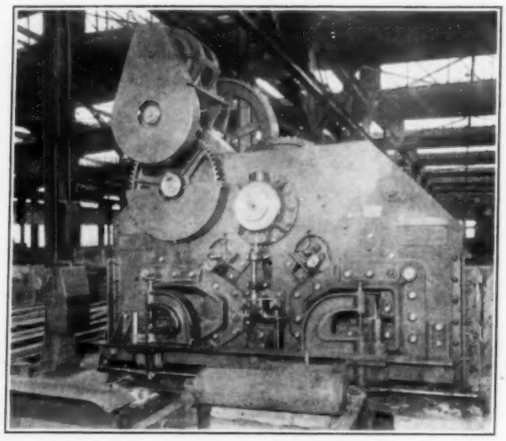
It pays.

Standard Underground Cable Co.

Division of General Cable Corp.

General Offices: **PITTSBURGH, PA.**

Boston Philadelphia Atlanta Chicago
St. Louis Seattle New York Washington
San Francisco Detroit Kansas City Los Angeles
Birmingham Charlotte



Steel Mill Installation on double ended shear using Rowan Type 9000-B Oil Immersed Impedance Starter.

Type 9000-B Impedance Starters have the following essential features for Steel Mills and other applications.

1—All working parts are completely oil immersed, therefore always lubricated and accurate in operation.

2—Impedance coils located so that they are easily accessible and adjustable.

3—All parts are ruggedly constructed and enclosed in a heavy sheet steel cabinet, carefully welded, making them dust-proof and weather-proof.

4—Completely protects motor against overloads, Short Circuits and single phase operation by means of accurately, calibrated magnetic overload relays which are not effected by ambient temperatures.

Write for further information regarding this Heavy Duty Impedance Starter.

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

Good and extra good air filtration . . . . . The "SUPER-HOOKUP"

HERE'S a new idea embodying old principles. It is nothing more startling than a combination of two air filters—arranged in tandem form. We call it our "Super-Hookup" for want of a better name. It is intended only for such jobs as require more complete dust elimination than is possible with any air filter of the viscous film type.

There are problems of this nature in every steel mill. At least, we have formed this conclusion from the numerous requests we get from mill engineers. The "Super-Hookup" is an excellent solution for such special cases as require extreme efficiency in the face of heavy dust concentrations.

The TooPas is an air filter using oil as a cleaning agent. Its efficiency is very high and it catches everything but the very fine dust that no filter of this type can get and which is not harmful in ordinary applications. Its vertical form makes it adaptable to fit into the combination as a pre-cleaner.

The AIRMAT is a filter embodying the new dry fibrous textured sheet as the cleaning agent. It has already become recognized as the only commercial filter capable of stopping microscopic dust particles.

Air passing through this combination is cleaned as in no other process now known.

We will be glad to tell you whether the "Super-Hookup" is applicable to your particular problem.

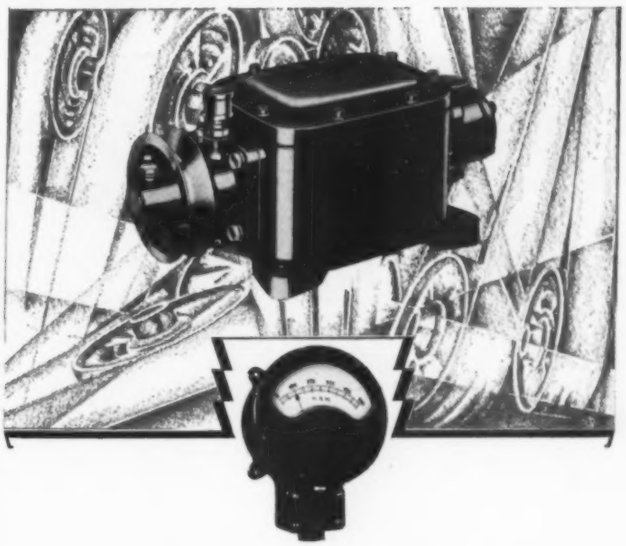
Send for valuable bulletins.

NATIONAL AIR FILTER COMPANY

5130 Ravenswood Avenue

Chicago, Illinois

I&SE12—Gray



INDUSTRIAL SPEED CONTROL

A STUDY of modern industrial operation reveals the great importance of speed regulation. In the production of the raw products of the mine—in the development of water power and other natural resources—in railway, marine and automotive fields—and in an infinite variety of manufacturing plants of every size—speed regulation is of vital importance.

Both quantity and quality production methods demand this regulation. It is made necessary by the prevalence of high speed tools and machines as a measure of protection to expensive equipment and as a sure means of controlling production operations where it is desired to maintain certain speed constants.

The Weston Electric Speed Indicator is, therefore, a most important development which has wide application to industry and commerce generally. It is extremely precise, yet rugged and dependable and is applicable to all forms of rotational machinery.

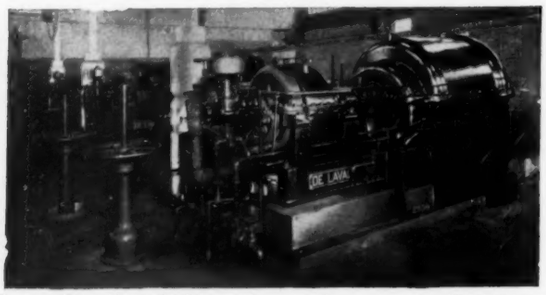
The Weston Electric Speed Indicator consists of a Model 44 Magneto and one or more Weston voltmeter indicators, calibrated in any desired units of measurement. These electric tachometers are furnished in several types depending upon the intended service and the nature of the installation.

The magneto generates a voltage directly proportional to its driven speed, and this voltage is transmitted by cables to indicators which may be located at any points remote from the device whose speed is being measured. Accuracy is independent of size or length of the connecting cables.

Its operation is smooth and positive. The same dependable performance is guaranteed for this equipment as for other Weston instruments. Every business executive should investigate the unusual merits of this most reliable type of all speed indicators. Complete descriptive literature for the asking. Write direct to

WESTON ELECTRICAL INSTRUMENT CORP.
609 Frelinghuysen Ave. Newark, N. J.

Weston PIONEERS SINCE 1888 INSTRUMENTS



Three De Laval four-stage coke oven exhausters; 18,750 cu. ft. of coke oven gas per min. each against a maximum pressure of 4.58 lbs. at 3700 RPM.

for Uninterrupted Operation

DE LAVAL CENTRIFUGAL COMPRESSORS are characterized by low rotative and low peripheral speeds, heavy and rigid shafts, large internal clearances, effective water cooling where necessary, highest grade materials and workmanship, and high guaranteed efficiencies.

DE LAVAL STEAM TURBINES are of the impulse type, having large clearances, and have been specially designed for modern steam pressures and superheats and to utilize high vacua.

Both turbine and compressor cases are split horizontally and all internal parts are easily accessible. They are made throughout to limit gages on an interchangeable basis and are guaranteed as to efficiency and other operating characteristics.

The photograph shows three De Laval turbine driven four-stage exhausters designed to deliver 18,750 cu.ft. of coke oven gas per minute each against a maximum pressure of 4.58 lbs., when running at 3700 r.p.m.

Ask for Catalog F-150

De Laval
Steam Turbine Company
Trenton, New Jersey

Local Offices: Atlanta, Boston, Charlotte, Chicago, Cleveland, Duluth, Havana, Helena, Honolulu, Houston, Kansas City, Los Angeles, Montreal, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., St. Paul, Salt Lake City, San Francisco, Seattle, Spokane, Toronto, Vancouver.

705

Manufacturers of Steam Turbines, Centrifugal Pumps, Centrifugal Blowers and Compressors, Flexible Couplings, Double Helical Speed Reducing Gears, Worm Gears, Hydraulic Turbines and Special Centrifugal Machinery.

Pittsburgh District Section

SATURDAY,
JANUARY 5, 1929

A SYMPOSIUM COVERING LUBRICATION

BY

L. P. TYLER, Vacuum Oil Co., Pittsburgh, Pa.

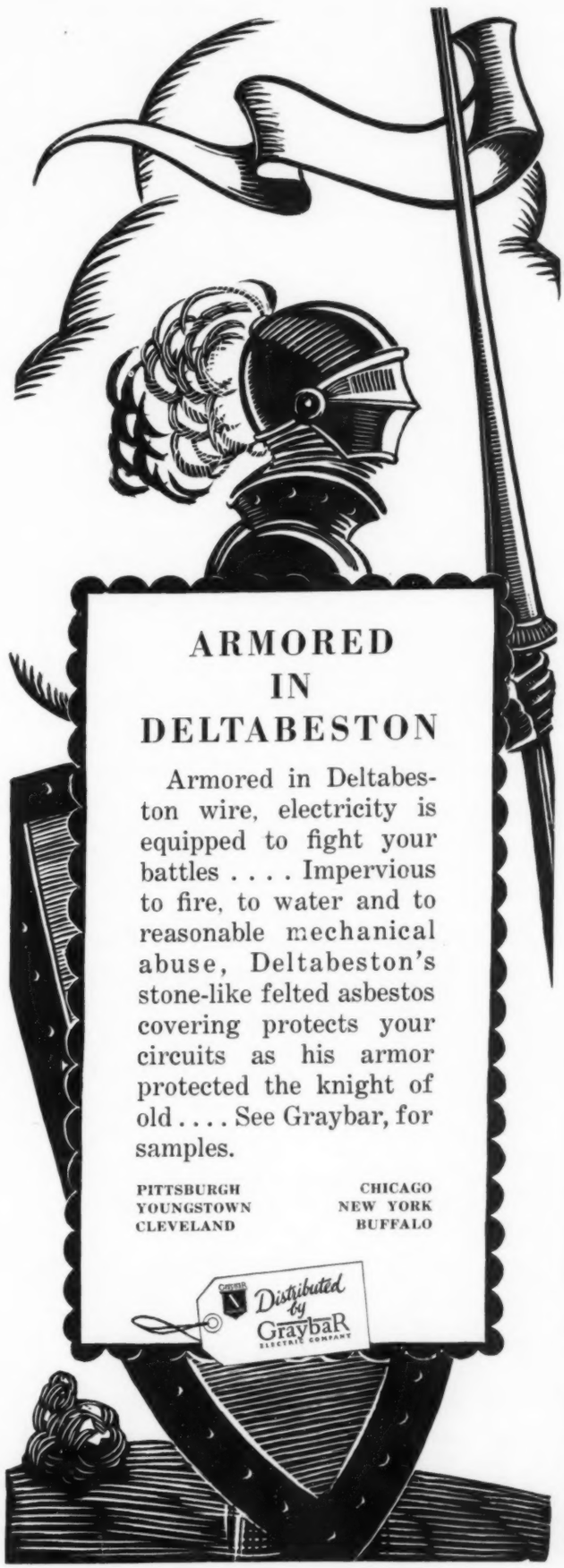
C. W. BYDEN, De Laval Separator Co., New York, N. Y.

C. O. NORSTRUM, Keystone Lubricating Co., Philadelphia, Pa.

DINNER 6:30 P. M.
ENTERTAINMENT 7:00 P. M.
TECHNICAL SESSION 8:00 P. M.

Blue Room — Wm. Penn Hotel

Pittsburgh, Pa.



ARMORED IN DELTABESTON

Armored in Deltabeston wire, electricity is equipped to fight your battles . . . . Impervious to fire, to water and to reasonable mechanical abuse, Deltabeston's stone-like felted asbestos covering protects your circuits as his armor protected the knight of old . . . . See Graybar, for samples.

PITTSBURGH CHICAGO
YOUNGSTOWN NEW YORK
CLEVELAND BUFFALO

Distributed by GraybaR ELECTRIC COMPANY

TOULOUMBAJIS

In certain sections of Constantinople the touloumbajis, or irregular firemen, run to a fire with a simple pump mounted in a packing box.

Arriving on the scene they start to haggle with the owner of the building on a price to save either the house or the furniture.

In other words, their first interest is to see how much money they can get out of the emergency.

Thank goodness that element has been largely eliminated from carbon brush application.

Fact is since the widespread adoption of the Morganite method of selling brushes on engineering prescription, emergencies don't arise.

Morganite

Main Office and Factory
3302-3320 *Anable Ave., Long Island City, N. Y.*

DISTRICT ENGINEERS AND AGENTS

Pittsburgh, Electrical Engineering & Mfg. Co., 909 Penn Avenue.

Cleveland, Electrical Engineering & Mfg. Co., 422 Union Building.

Baltimore, O. T. Hall, Sales Engineer, 437-A Equitable Building.

Revere, Mass., J. F. Drummey, 75 Pleasant Street.

Los Angeles, Electrical Engineering Sales Co., 502 Delta Building.

San Francisco, Electrical Engineering Sales Co., 222 Underwood Building, 545 Market Street.

Toronto, Can., Railway & Power Engineering Corp., Ltd., 133 Eastern Ave.

Montreal, Can., Railway & Power Engineering Corp., Ltd., 898 St. Antoine St.

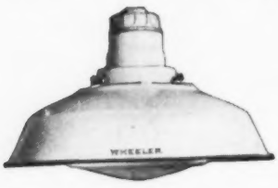
Winnipeg, Can., Railway & Power Engineering Corp., Ltd., P. O. Box 325.

WHEELER REFLECTORS

for every industrial lighting need

Wheeler Durex

"Easiest-to-Wire" DUREX Fixtures for all Industrial Lighting. Patented construction—only three steps required to install. Contacts easily wired—cap quickly screwed on—and reflector attached with few twists of the wrist. Available in R.L.M. Standard Dome, Shallow Dome and Angle types. For 25 to 1000 watt lamps.



Glassteel Diffuser

For use in factory work rooms and offices where fine operations require minimized shadows. Furnished complete, ready for wiring, with standard DUREX cast canopy. This provides the easiest possible wiring because of the short canopy which makes socket readily accessible. Standard white finish with white diffusing globe. Available for use with 100 to 500 watt lamps.

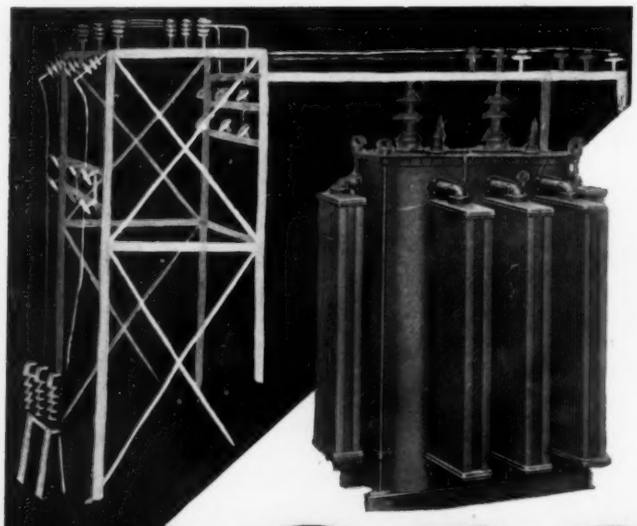
Wheeler Vapolux

For lighting where vapor conditions exists, VAPOLUX is the only safe unit. It is all enclosed—a special convex glass disc being tightly sealed into the mouth of the reflector by two asbestos gaskets and an aluminum ring. Made in Angle and Bowl Types also. Sizes for 50 to 500 watt lamps.

—Send for Wheeler Catalog—

DOUBLEDAY-HILL ELECTRIC CO.

110-112 Seventh St. **Pittsburgh, Pa.**

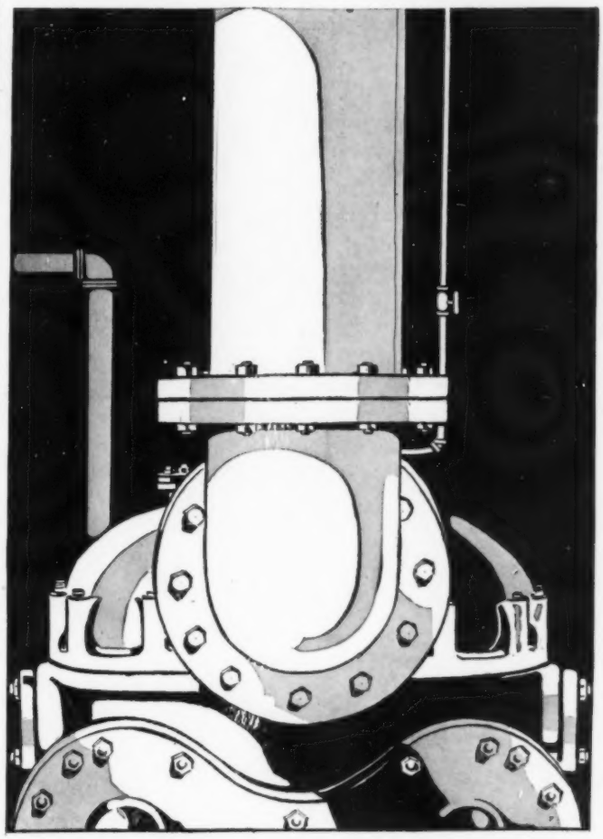


Specify

Moloney Transformers for power transmission and distribution—be assured of Service and economy.

MOLONEY ELECTRIC COMPANY
Main Office and Factories: ST. LOUIS, MO.
Sales Offices in Principal Cities

MOLONEY TRANSFORMERS



VULCABESTON

THE properties of asbestos which give it its great resistance to heat are equally valuable not only in rendering

VULCABESTON PUMP VALVES

impervious to oils, acids, brine and other erosive chemicals, but in giving them the most extraordinary strength for withstanding pressure and toughness for resisting the wear of friction.

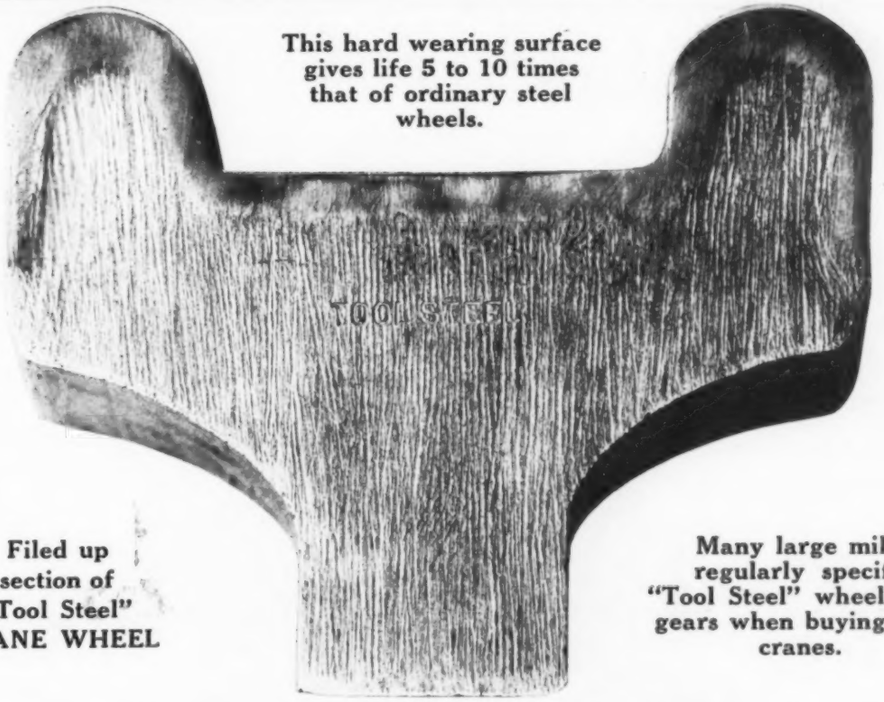
Remember the name

VULCABESTON

the buyword of those who know the economy of quality.

COLT'S PATENT FIRE ARMS MFG. CO.
MECHANICAL GOODS DIVISION
HARTFORD, CONNECTICUT, U. S. A.
NEW YORK · BOSTON PHILADELPHIA · PITTSBURGH · CHICAGO SAN FRANCISCO 33-P-28A

This hard wearing surface gives life 5 to 10 times that of ordinary steel wheels.

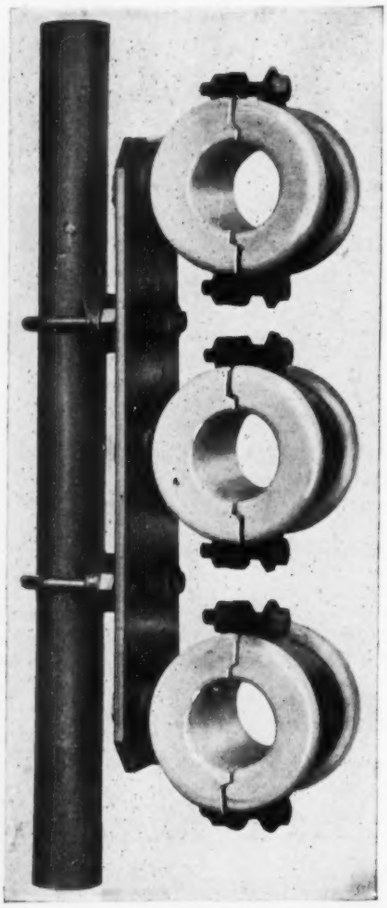


Filed up section of "Tool Steel" CRANE WHEEL

Many large mills regularly specify "Tool Steel" wheels and gears when buying new cranes.

The Tool Steel Gear & Pinion Co.

CINCINNATI, OHIO



A New and Better Line of Clamp Insulator Cable Supports

Appearance—strength—safety—simplicity of design—ease of installation! You can call the *entire roll* of desirable characteristics—and in every instance this new line of cable supports will *meet them.*

Here, in a *price class* where ordinary equipment has always been accepted as inevitable, *is offered* a finish, a design and workmanship that you would only expect in higher voltage *and* higher priced equipment.

—porcelain spools with smooth surfaces, uniform glazing and good appearance.

—malleable supporting castings the same in quality as used in our standard UNIT TYPE high voltage equipment.

—hard brass, springy bands to firmly clamp the porcelain spools against the malleable iron fittings—eliminating looseness.

—bolts with clean-cut threads so that the nuts will easily run on and set against heavy lock washers.

—identification marks on the parts and fittings—saving your time.

You'll find quality and service you *never* thought possible in low priced equipment—it's *another* UNIT TYPE standardized product.

(Ask For Bulletin 31-F)

Delta-Star Electric Co

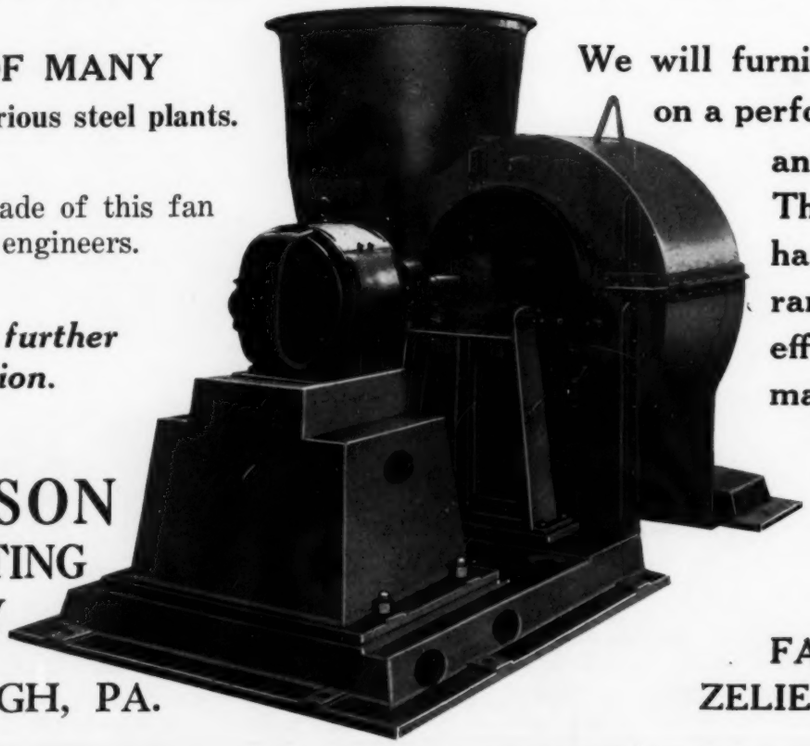
2400 Block, Fulton Street - CHICAGO, ILLINOIS

ROBINSON BLAST FURNACE STOVE FAN

ONE OF MANY
installed in various steel plants.

A test was made of this fan by consulting engineers.

Write us for further information.



We will furnish these fans on a performance guarantee basis. This New Fan has a very wide range of high efficiency and maintains its volume with variations in pressure.

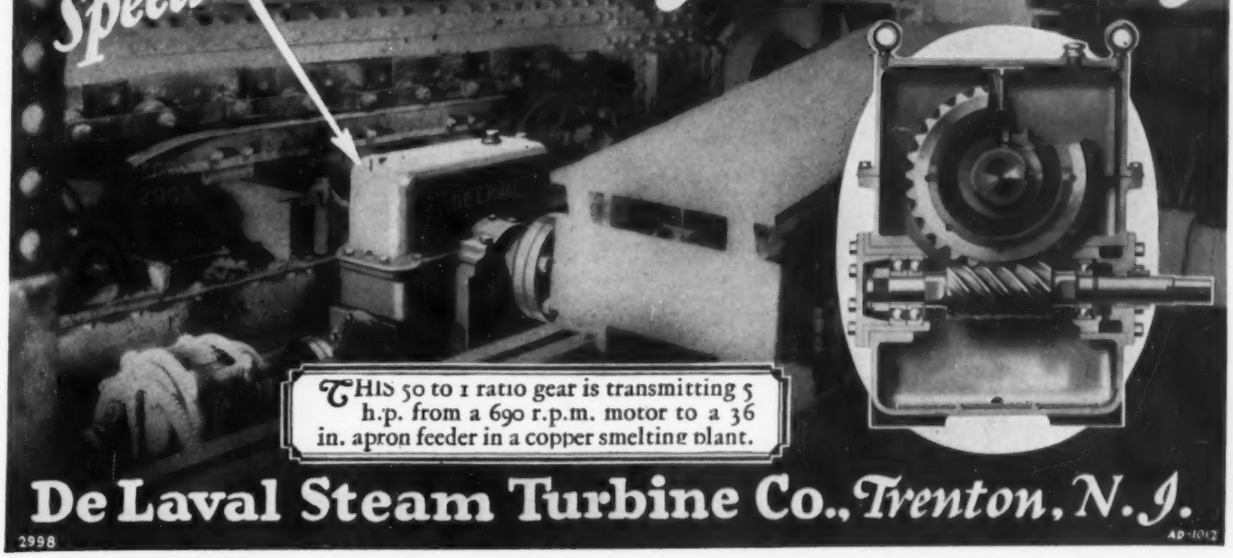
ROBINSON VENTILATING COMPANY

PITTSBURGH, PA.

FACTORY
ZELIENOPLE, PA.

De Laval Worm Gear

A Superior Speed Reducer for driving heavy machinery



THIS 50 to 1 ratio gear is transmitting 5 h.p. from a 690 r.p.m. motor to a 36 in. apron feeder in a copper smelting plant.

De Laval Steam Turbine Co., Trenton, N. J.

2998 AD-1012

Noark

Strain Insulators

General Specifications

Clevises taking 3/8" bolt
have a spread of 9/16"
Clevises taking 1/2" bolt
have a spread of 11/16"
Clevises taking 3/4" bolt
have a spread of 15/16"
No. 0 Diameter 3"
Breaking Strain 10,000 lbs.
No. 1 Diameter 2-5/8"
Breaking Strain 8,000 lbs.
No. 2 Diameter 2"
Breaking Strain 5,000 lbs.

NOARK Giant Strain Insulators are constructed of the highest grade of insulating materials and metal parts. The Eyes, Clevices and Studs are made of drop steel forgings, sherardized. All stresses between metal parts are protected by heavy sheet mica. The body of the insulators is composed of molded insulation. Every insulator is thoroughly tested before leaving the plant, and the factor of safety is greatly in excess of their catalog rating.

"They Blow on the Dot"

COLT'S PATENT FIRE ARMS MFG. CO.
ELECTRICAL DIVISION
HARTFORD, CONNECTICUT, U. S. A.
NEW YORK · BOSTON PHILADELPHIA PITTSBURGH · CHICAGO SAN FRANCISCO 33-EX-69-A

Ask for what you want
Get what you ask for

but be sure to ask for

USG

BRUSHES

Carbon Graphite Metal-Graphite

A Grade for every purpose

SHALL WE SEND SOME SPECIFICATION SHEETS TO HELP YOU ORDER?

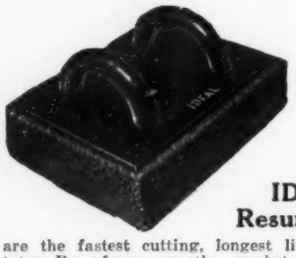
THE UNITED STATES GRAPHITE COMPANY

FACTORY AND MAIN OFFICE—Saginaw, Mich.

DISTRICT SALES OFFICE

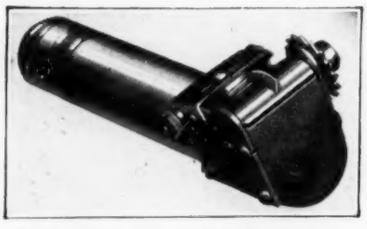
NEW YORK 50 Church St. | *PHILADELPHIA* 1500 Walnut Street | *PITTSBURGH* 1229 Fulton Bldg. | *CHICAGO* 1301 Railway Exchange Bldg. | *ST. LOUIS* 2018 Railway Exchange Bldg.

IDEAL TOOLS for every phase of COMMUTATOR MAINTENANCE



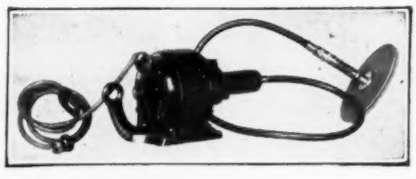
IDEAL Resurfacers

are the fastest cutting, longest lived Commutator Resurfacers on the market. Noted for their fast, free-cutting and non-copper collecting advantages.



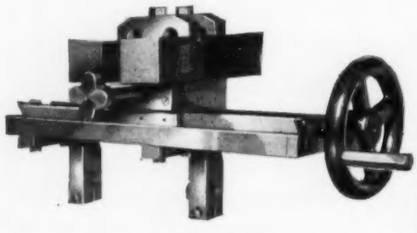
IDEAL Power Undercutter

handy and compact. Permits instant cutting as it is not necessary to remove brushes or rigging. Saves one to three hours on every job. No heating, no jerking, no jumping. Maintains commutator in a condition that prolongs life of brushes.



IDEAL Slot Cleaner

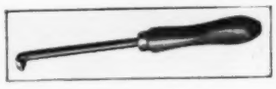
Ball bearing hand piece and disc holder attachment. Can be used as a unit with the Ideal Mica Undercutter. Especially adapted to cleaning old insulation out of armatures. Used also for other grinding and sanding work.



IDEAL Tool Rest

Designed for mounting on brush arm and insures a perfectly true job of resurfacing any Commutator in its own bearings, at normal speed. Eliminates gouging. Makes possible extreme accuracy, and prolongs life of Commutator.

IDEAL Slot Scraper



Especially designed for cleaning out slots after undercutting, and slightly beveling copper edges, removing possible burrs or fins in the copper or any obtruding parts of mica.

Ideal Commutator Dresser Co., 12-28
1045 Park Ave., Sycamore, Ill.
Please send [ ] Ideal Resurfacer [ ] Ideal Tool Rest
[ ] Ideal Power Undercutter [ ] Ideal Slot Scrapper
[ ] Ideal Slot Cleaner
on FREE trial.

Name.....

Address.....

City and State.....

ANY IDEAL TOOL ON FREE TRIAL

Ideal Commutator Dresser Co.

1045 Park Ave. Sycamore, Ill.

Easy Access

—promotes frequent cleaning of reflectors

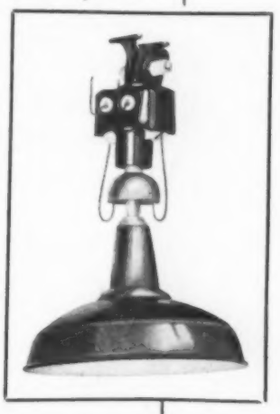
Clean reflectors put more light down in the working area.

Thompson Hangers are ideal for high lamps that are hard to reach or hung in places that are dangerous to workingmen.

The Hanger enables the lamp and reflector to be lowered to the ground, away from dangerous wires and dizzy heights.

Thompson Hangers are inexpensive—they can be installed in your present system—either indoors or out.

The Thompson Shock Absorber or Vibration Arrester, prolongs the life of costly bulbs; used with or without Thompson Hanger. Models and springs for different weights of lamps.



Write for illustrated booklet, and full details.

THE THOMPSON ELECTRIC COMPANY

1438 West Ninth Street **CLEVELAND, OHIO, U. S. A.**

LARGEST BUILDERS OF THE WORLD'S LARGEST CRANES

Alliance Products

STANDARD CRANES
Up to 430 tons capacity

STRIPPING CRANES
Up to 320 tons capacity

COMBINATION CHARGERS and STRIPPERS
Up to 200 tons capacity

- Ladle Cranes
- Ingot Strippers
- Soaking Pit Cranes
- Open Hearth Charging Machines
- Slab and Billet Charging and Drawing Machines
- Gantry Cranes
- Ore and Coal Bridges
- Car Dumpers
- Forging Manipulators
- Steam Drop Forge Hammers
- Coke Pushers, Levelers and Door Lifters
- Coal Pier Equipment
- Rolling Mill Machinery
- Cement Plant Machinery
- Dock Handling Equipment
- Coke Oven Equipment

234 of 100 Tons Capacity and over

LADLE AND STANDARD CRANES

58		100 tons
2		115 tons
4	WORM DRIVEN Ladle,	125 tons
44		125 tons
27		150 tons
3	WORM DRIVEN Ladle,	160 tons
2	WORM DRIVEN Ladle,	165 tons
3	WORM DRIVEN Ladle,	175 tons
26		175 tons
2		200 tons
1		225 tons
1		250 tons
1		275 tons
3		430 tons

STRIPPING CRANES

8		100 tons
1		125 tons
21		150 tons
15		200 tons
1	Single Ram,	320 tons

COMBINATION CHARGERS AND STRIPPERS

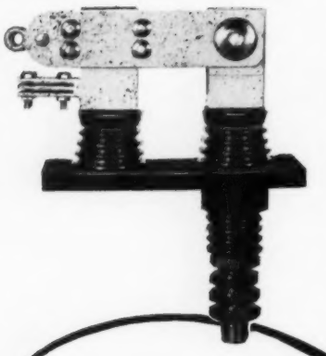
3		100 tons
1		125 tons
3		150 tons
4		200 tons

Give Us the Runway and We will Lift the World

THE ALLIANCE MACHINE CO.

ALLIANCE, OHIO, U.S.A.

ENGINEERS AND BUILDERS



Double Blade Switches
"Three E" Feature meaning
Cooler Operation
Greater Durability
and Better Contact

YOU CANNOT SUBSTITUTE FOR "THREE E" RELIABILITY

Get double blade benefits with less operating costs

The "Three E" organization was the originator of Double Blade Switch Construction. "Three E" Double Blade Switches are being extensively used today because they have conclusively demonstrated their superiority. Here again is a reason for the well known "Three E" * Service Value.

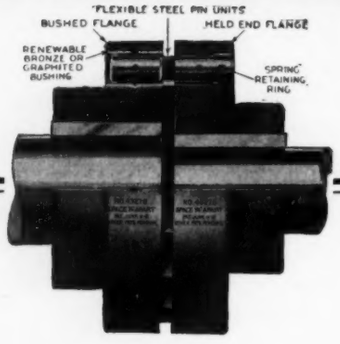
We will be glad to give you further details on "Three E" switches. Our Bulletin No. 112 shows the variety of Double Blade types we make.

"THREE E"
HIGH QUALITY
LINE AND STATION EQUIPMENT

*"Service Value" = Low cost per year of service

Electrical Engineers Equipment Co.
General Office and Factory: MELROSE PARK, ILL.
Chicago Office: 205 W. Wacker Drive.
Eastern Office: 21 Park Row, New York
Sales Offices in all principal cities
Canadian Representative Northern Electric Company LIMITED

It pays to use The 'Three E' WRITE FOR Catalogue



Note especially the improved construction in these bushed laminated-pin type FRANCKE couplings. Easy to install, satisfactory in service, and lower maintenance because they are all metal and no movement or wear on shaft flanges.

Over 71,000

FRANCKE
FLEXIBLE COUPLINGS

Since 1912

You will find them today improving the operation of machines everywhere, on direct-connected and geared, motor, turbine and engine drives.

Special features worth your careful attention include: Spring cushion for load shocks and vibration. Provision for handling all accidental shaft misalignments. More and easier endwise movement. Self-lubrication for most drives. Easy to line up, disconnect or assemble. Greater bore and power capacity, resulting in lower cost per unit.

Stock sizes up to 500-750 H.P.—larger sizes up to 5000 H.P. built to order.

Send for New Catalog No. 40

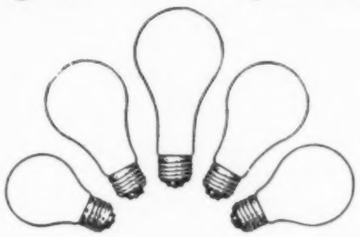
SMITH & SERRELL
Coupling Specialists Since 1912.
64 Washington Street, Newark, N. J.

Cut Your Costs

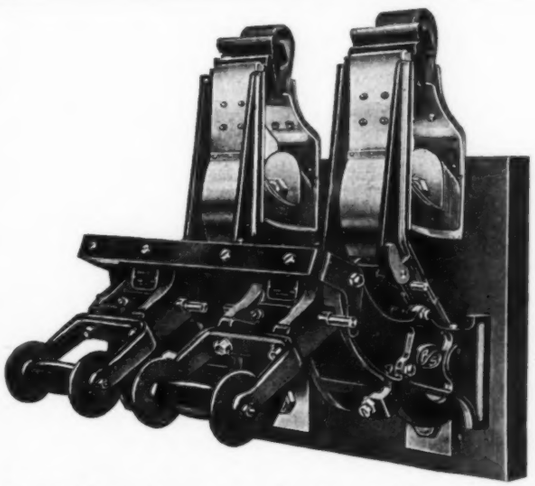
TEST after test has always given the same answer—good factory lighting increases production from 5 to 35%. The average increase in production is 15%, and the average cost of that better lighting is only 2% of the payroll.

Good light is one of the greatest cost cutters known. When you put a modern efficient installation in a plant, it's like putting 15 more good men on the job, and only paying for two of them.

National MAZDA Lamps are the heart of a good lighting installation. They are the best that men and money can make, and they sell today for less than they have ever sold before. They make good light the cheapest thing you can buy.



RUMSEY
ELECTRIC COMPANY
Electric Supplies and Machinery
Everything in Radio
1007 Arch Street
Philadelphia



A NEW BULLETIN ON

ROLLER-SMITH
CIRCUIT BREAKERS

Roller-Smith has just issued *new* Bulletin AK-530, covering its Standard Type Circuit Breakers. This Bulletin presents, clearly, comprehensively and in get-at-able shape, prices and technical data on a most complete line of carbon break circuit breakers.

If you would like a copy of this new Bulletin AK-530 write us or, better still, ask the R-S office nearest you. There is one, **and a circuit breaker sales engineer,** in every principal city in the United States and Canada, also in Australia, Cuba and Japan.

"Over thirty years' experience is back of ROLLER-SMITH"

ROLLER-SMITH COMPANY
Electrical Measuring and Protective Apparatus

MAIN OFFICE
2131 Woolworth Bldg., NEW YORK

WORKS
Bethlehem, Penna.

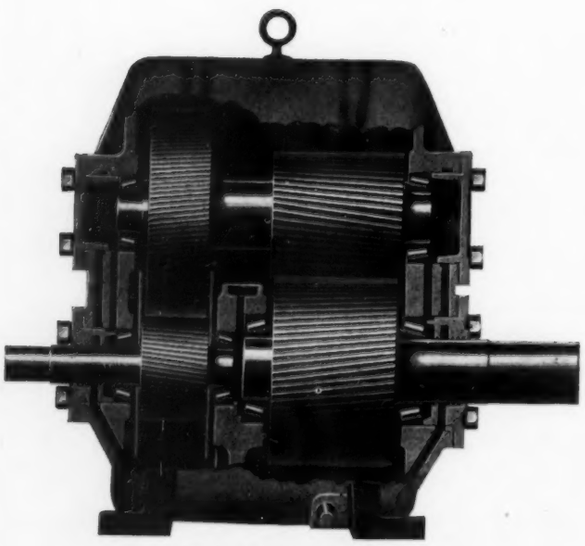
Offices in Principal Cities in U. S. and Canada
Representatives in Australia, Cuba and Japan

Costly Exposed Gearing Gives Place to Compact Modern Units

Westinghouse-Nuttall Speed Reducers, manufactured by the R. D. Nuttall Co., Pittsburgh, Pa.—Sturdy, smooth, running helical gears, turning on Timken Roller Bearings, totally enclosed and bathed in oil, take the place of massive spurs exposed to the abrasive dust and dirt of most any application. Not only is the up-to-date installation more compact, more efficient and more dependable, but it requires practically no maintenance where the old set-up needed constant attention.

Nuttall reducers are extremely simple in design and when adjustment is necessary it requires less effort—less time-giving, more speed—more profit. Depend upon it Nuttall Speed Reducers give you real value for your Mill Drive Dollars. Consider them in terms of wear and production.

Single reduction from 4 hp. up to 450 hp. with a maximum ratio 8:1. Double reduction from 3 hp. up to 200 hp. with a maximum ratio of 47:1.



Nuttall Type DVR
Double Reduction Speed Reducer, 47:1 Ratio.

Send for Speed Reducer Bulletin No. 59

All Westinghouse-Nuttall Products are sold thru the Westinghouse Electric & Mfg. Co., district offices. Refer your inquiries to the nearest Westinghouse office.

Lyman Tube & Supply Co., Montreal, Toronto and Vancouver, Canada

Westinghouse-Nuttall

Are you interested in long life insured by—

OHIO MAGNET

Characteristics

1. All impregnated asbestos insulation makes the Ohio the only magnet that will stand up for years without coil breakdown on continuous magnetic separation work or the handling of hot materials.

2. Outer ring bolts on top, protected and no thru holes avoid ring breakage.

3. Graphitized asbestos gaskets keep the impregnating compound in and moisture out.

4. Coil clamped tight between top and bottom keeps the Ohio Magnet cooler and lifting capacity up.

5. Heavy insulation and adequate protection from mechanical injury avoids terminal and lead troubles.

6. All bolts are nickel alloy heat treated. They do not break.

7. All bolts are positively locked. They do not loosen.

8. The outside contours of Ohio Magnets are all rounded. They do not catch on obstructions or injure the sides of cars.

9. Steel parts are fairly uniform in cross-section so they cast solid with no blow holes.

10. Due to its efficient design and use of materials the Ohio Magnet is the lightest magnet but has maximum lifting capacity.

N. B.—Read points No. 1 and 10 again.

P. S.—Because of long life and low upkeep cost Ohio Magnets earn big profits where they can be used for magnetic separation or handling hot or cold materials.

P. P. S.—It is the reasons above and hundreds in successful operation that we are justified in calling them OHIO RELIABLE MAGNETS.

The

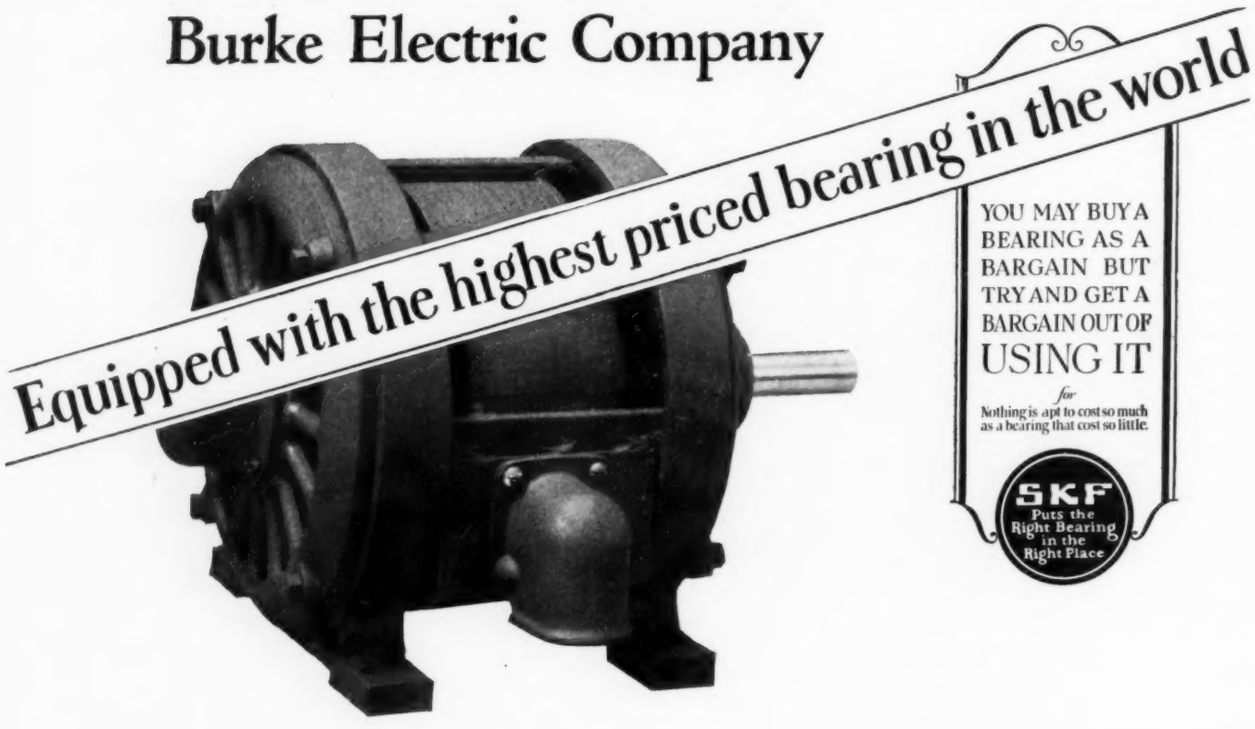
Ohio Electric & Controller Co.

5903 Maurice Avenue

Cleveland, Ohio

ANOTHER ONE OF THE 59 ELECTRICAL MANUFACTURERS THAT USES SKF BEARINGS

Burke Electric Company


Equipped with the highest priced bearing in the world
YOU MAY BUY A BEARING AS A BARGAIN BUT TRY AND GET A BARGAIN OUT OF USING IT
for
Nothing is apt to cost so much as a bearing that cost so little.
SKF
Puts the Right Bearing in the Right Place

Motors Large and Small Give the Least Trouble with SKF Bearings

MOTORS everywhere . . . . large and small . . . . turning smoothly and easily . . . . transferring energy without interruption or troublesome maintenance. The march of progress toward such unfailing motor performance has been due in great measure to the use of anti-friction bearings. Today, 59 manufacturers in the electrical industry are using SKF Ball and Roller Bearings because of their many proven advantages.

For years the Burke Electric Company has been using SKF Bearings on motors. Losses of productive time and high repair costs due to bearing wear are reduced to a minimum. SKF Bearings never require any adjustments, maintain initial air gap, eliminate damaged rotors and windings, and require lubricant but three or four times a year. To the ultimate user all these things mean . . . . service which is the lowest in cost per bearing hour.

SKF INDUSTRIES, INC., 40 East 34th Street, New York, N. Y.

2166

SKF

Ball and Roller Bearings

Permanent Protection

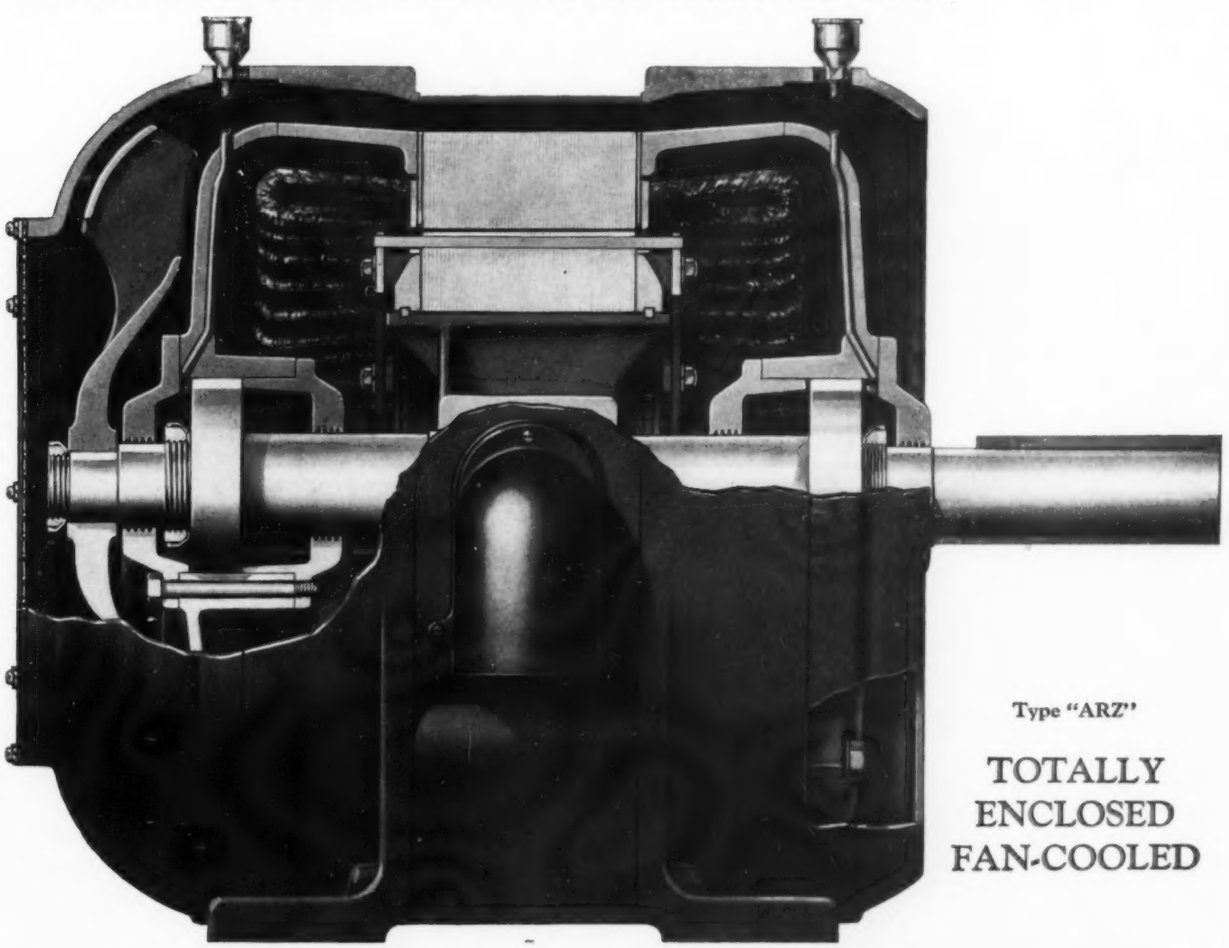
THE only permanent protection the coils of a motor have against destruction from acids, alkalis, metallic dust, and the clogging of air passages, is to seal them against contact.

Allis-Chalmers Manufacturing Company has developed a new type of motor wherein this protection is accomplished without appreciable increase in weight or mounting space over the standard open type motor.

Simplicity of design and sturdy mechanical structure characterize this new motor. Solid cast iron bearing housings with grease-packed bearings form the end closures. Safe temperatures are maintained by blowing a sufficient volume of cooling air around and across those parts which conduct the heat from the interior to the outer surfaces. A circumferential air jacket controls the flow of cooling air.

All well known basic features of Allis-Chalmers motor design are maintained.

ALLIS-CHALMERS MANUFACTURING CO., MILWAUKEE, WISCONSIN

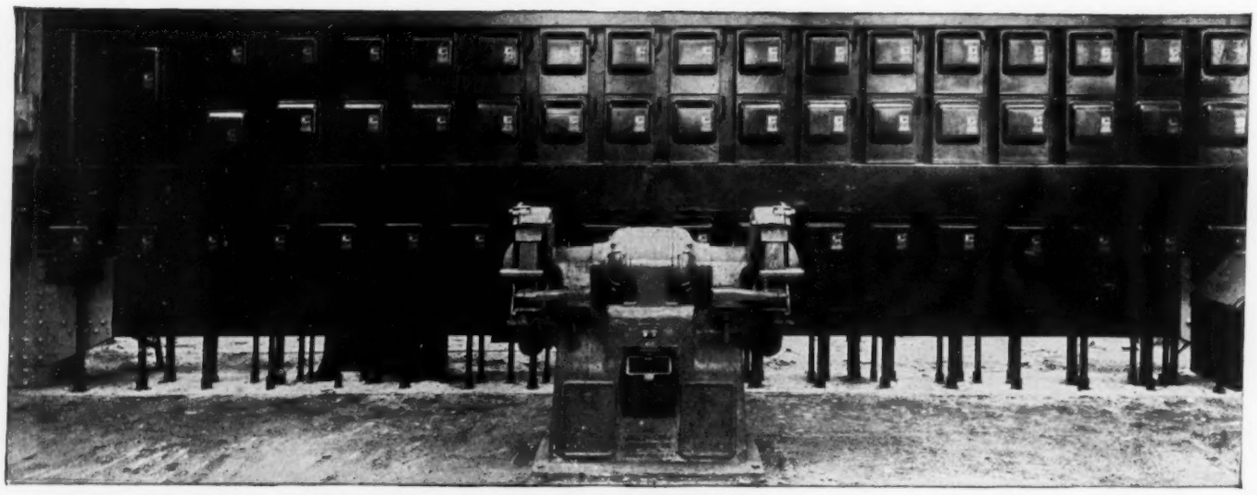


Type "ARZ"

TOTALLY ENCLOSED FAN-COOLED

ALLIS-CHALMERS MOTORS

Ⓣ Trumbull Switches for Steel Mills and Industrial Plants



Type "A" Safety Switch Control Board, Consisting of 50 Switches, Installed in a Large Railroad Shop.

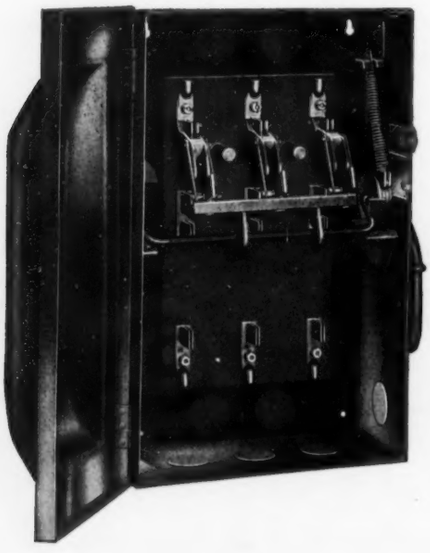
The following are Trumbull Switches specifically adapted for mill work:

A. MOTOR CIRCUIT SWITCHES—Unfused Type A Switches for starting motors across the line, rated in maximum Horse Power.

B. SWITCHES TESTED AND APPROVED FOR BREAKING FULL RATED LOAD—30—400 Amp., 250—600 Volts; 600—1200 Amp., 250 Volts; equipped with snuf-arcs.

C. "R.M." MOTOR STARTING SWITCHES—
1. Two Position.
2. Equipped for use with Thermal Cutouts.

D. MAGNETIC SWITCHES—Remote and Local Control. In drawn steel or cast iron boxes. Also made with Disconnect Switch in the same box. Relays either self-resetting or hand-resetting.



E. A complete line of various types of Disconnect Switches as well as Switches for Entrance work.

Bulletin 7 lists our entire line of Safety Switches. If you do not have a copy, be sure to write.

The Trumbull Electric Mfg. Co.

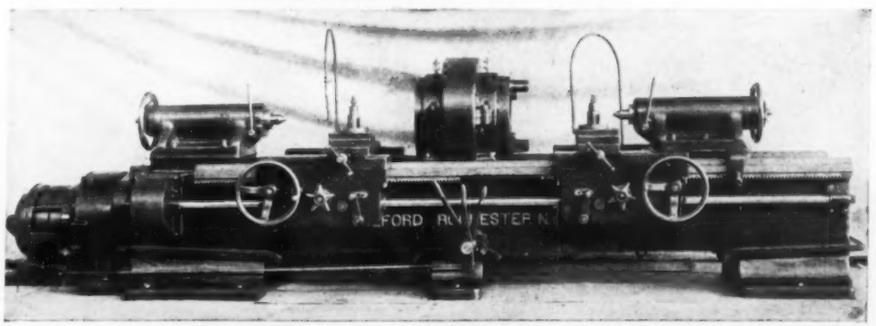
Plainville, Conn.

NEW YORK 114 LIBERTY ST.
BOSTON 1002 STATLER BLDG.
SAN FRANCISCO 595 MISSION ST.
CHICAGO 2001 W. PERSHING RD.
PHILADELPHIA BOURSE BLDG.
LUDLOW, KY. ATLANTA, GA.

The UNIVERSAL APPLICATION of The Gear with a backbone

FARREL-SYKES Gears have demonstrated their superiority in every field of industry where power is transmitted thru gearing.

High speed turbine gears running at 10,000 r.p.m., steel mill drives transmitting up to 10,000 HP thru one pair of gears, timing gears for gasoline engines, main drives for lathes, planers and drills all establish the high mechanical efficiency and absolute reliability of the "gear with a backbone"; and it is well to remember that they cost no more than an accurate straight tooth gear.



Write for details of our Roller Bearing Speed Reducers

FARREL-BIRMINGHAM CO., INC.

SUCCESSORS TO
FARREL FOUNDRY & MACHINE CO, ANSONIA, CONN. AND
BUFFALO, N.Y. AND BIRMINGHAM IRON FOUNDRY OF DERBY, CONN.
ADDRESS REPLIES TO THIS ADVERTISEMENT TO BUFFALO PLANT
344 VULCAN ST., BUFFALO, N. Y.

PYLE-NATIONAL Vaporproof Fittings are sealed against the admittance of dust, moisture and gases and have that enduring practical construction that recommends them for use in any industrial lighting service such as

Substantial bases provided with large wiring space—

Cast guards of ample size and strength to properly protect the glass globes—

Heavy duty Bakelite lamp receptacles—

Well molded glass globes—

Simple arrangement of all parts.

The Pyle-National Company

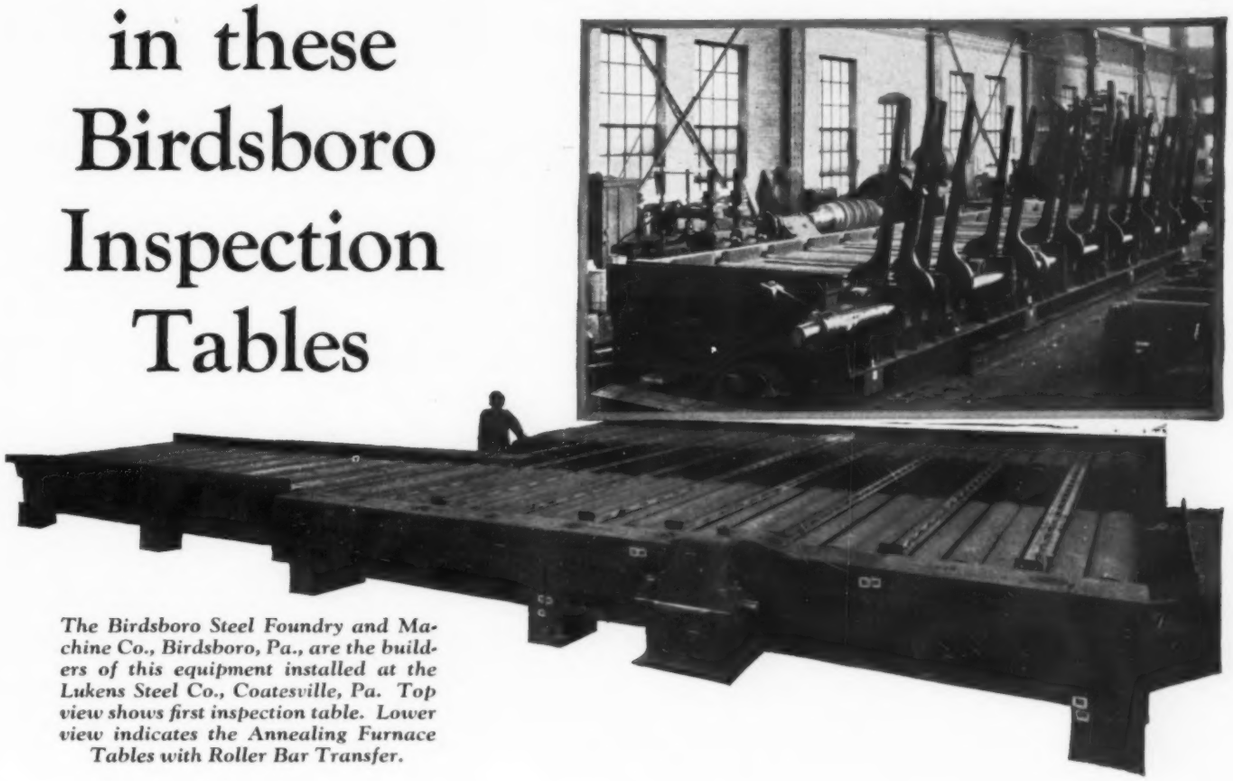
1334-1358 N. Kostner Avenue ~ Chicago, Ill., U. S. A.

EXPORT DEPARTMENT
International Railway Supply Co.
30 Church Street, New York City

BRANCH OFFICES
3509 Grand Central Terminal, New York City
815 Boatmen's Bank Bldg., St. Louis, Missouri
311 Builders Exchange Bldg., St. Paul, Minnesota
2241 Oliver Bldg., Pittsburgh, Pennsylvania
716-718 Little Bldg., Boston, Massachusetts
1000 Marine Bank Bldg., Houston, Texas

CANADIAN AGENTS
The Holden Company, Ltd.
Montreal, Toronto, Winnipeg, Vancouver

Hundreds of Hyatts in these Birdsboro Inspection Tables



The Birdsboro Steel Foundry and Machine Co., Birdsboro, Pa., are the builders of this equipment installed at the Lukens Steel Co., Coatesville, Pa. Top view shows first inspection table. Lower view indicates the Annealing Furnace Tables with Roller Bar Transfer.

Loss of time inspecting steel plates has been eliminated in the Lukens Mill by the adoption of Birdsboro Hyatt equipped mechanical plate turnovers.

Only anti-friction bearings—Hyatts—should be used for such an important assignment. For Hyatt bearings banish the sticking, grabbing action of brass journals which cause wear, replacements and costly delays.

In addition, Hyatt economies in labor and maintenance have won them overwhelming preference for all steel mill applications. Infrequent lubrication is their only attention.

Wherever the giant tasks demand uninterrupted production and freedom from breakdowns, Hyatts are your best assurance of lasting bearing satisfaction.

HYATT ROLLER BEARING COMPANY
Newark Chicago Detroit Pittsburgh Oakland

HYATT
ROLLER BEARINGS
PRODUCT OF GENERAL MOTORS

Do You Know of a Fuse That Will Equal This?

August 20th I wired the factory for ten 60020 and fifty extra renewal elements, for this customer. The chief electrician stated that if the fuses held and did not blow within one week, he would buy them.

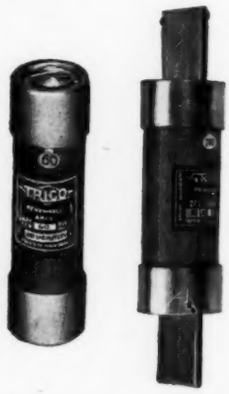
The Trico Renewal Fuses were installed August 23rd. On Oct. 25th, two months later, I called to check up on them. To date they had not blown once. Two other makes which they tried out blew on an average of twice a day.

O. R. Holgo

Just think of it! **Not once did the Trico Renewable Fuses blow!**
(NOTE—These are standard fuses and conform to the Underwriters' Laboratories Requirements)

Does not the above letter prove to you that **there is a difference** in fuses?

This experience is another triumph for the powder-packed element and the copper-to-copper contact **found only in TRICO Renewable Fuses.**



Ask for folder 206-B, which describes fully the exclusive features and the money-saving advantages of TRICO RENEWABLE FUSES.

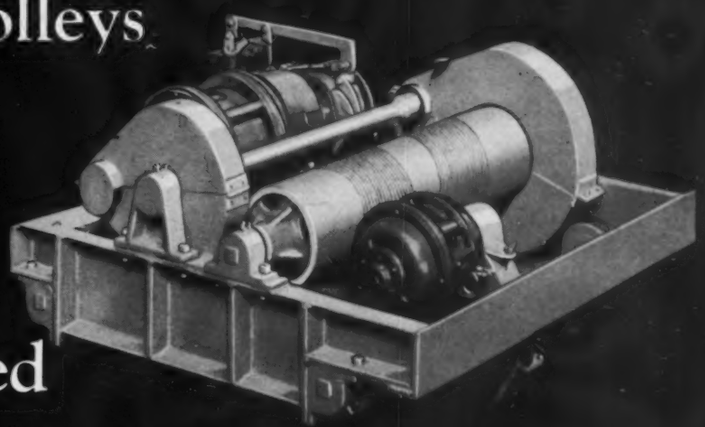
The **only** renewable fuses with "Powder-Packed" Renewal Elements at the price of the lonely bare link.

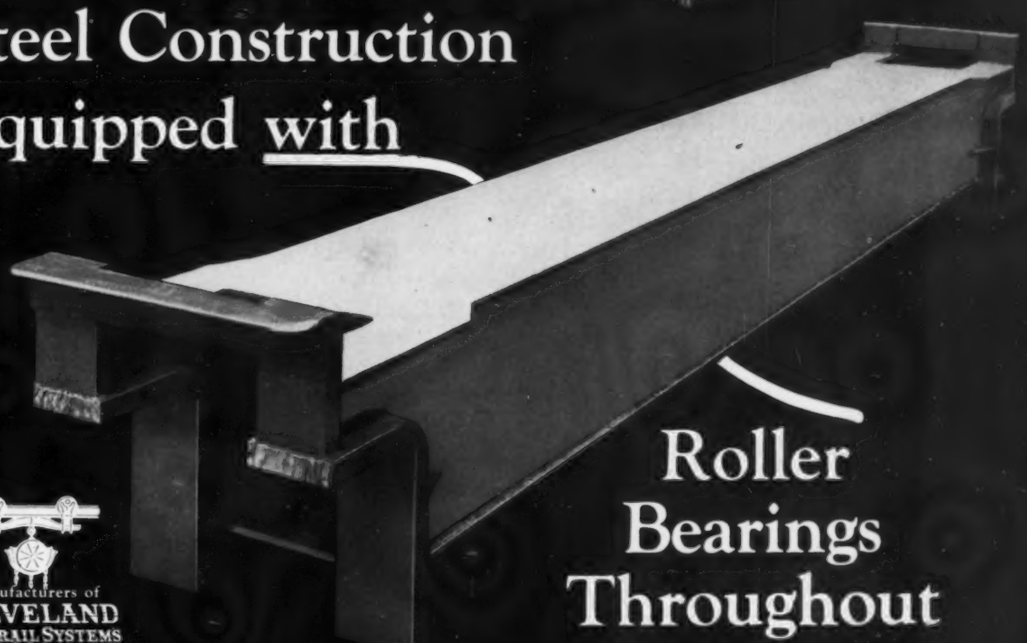
TRICO REG. U. S. PAT. OFF. **Renewable** FUSES

TRICO FUSE MFG. CO., 1006 McKinley Ave., Milwaukee, Wis.

Cleveland Crane offers

one-piece Trolleys
and
one-piece
End Trucks
of Arc Welded
steel Construction
equipped with





Roller
Bearings
Throughout

Manufacturers of
CLEVELAND
TRAMRAIL SYSTEMS

The Cleveland Crane & Engineering Company, *Wickliffe, Ohio*

50 Church Street
New York City

512 Farmers Bank Building
Pittsburgh, Penna.

557 Railway Exchange Building
Chicago, Illinois

CLEVELAND CRANES

All Sizes for
Every Service

UNDER excessively heavy loads—as under shock, jar, vibration and heavy overloads—the sturdy **"Hoffmann"** Precision Roller Bearing stands more, lasts longer, costs less. Its worth—in your equipment—is to be measured by what it does, not by what it costs.

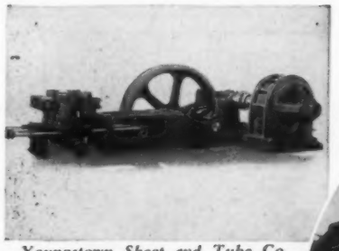
Catalogs 904 and 917.

NORMA-HOFFMANN BEARINGS CORPORATION

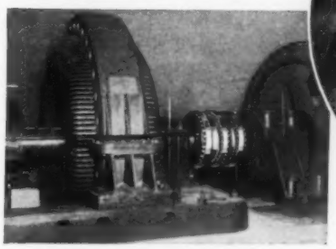
Stamford - Connecticut

PRECISION BALL, ROLLER AND THRUST BEARINGS

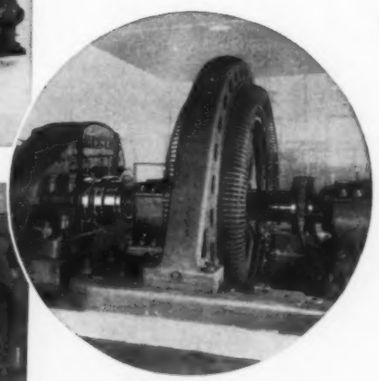
N 67



Youngstown Sheet and Tube Co.



Pittsburgh Crucible Steel Co.



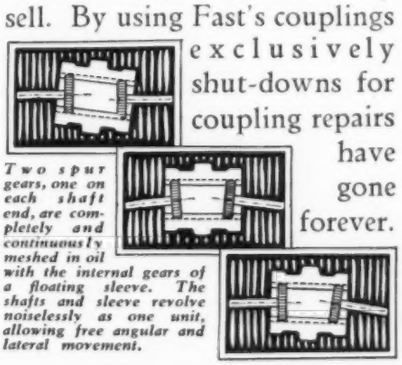
Mansfield Sheet and Tin Plate Co.

Shut-downs now avoided by eliminating "Flexible" Couplings

Instead, use Fast's self-aligning couplings which have no flexible parts.

AS LONG as there is any flexible material between your source of power and your driven machine, you are inevitably faced with the probability of failure and shut-down for repairs. Any flexible coupling built on old practice of using flexible bushings, pins, springs, discs or grids, keeps your plant subject to shut-down when you least expect it.

Since 1920 this has been avoided in thousands of plants. Scores of the country's largest equipment manufacturers have avoided it on machines they sell. By using Fast's couplings exclusively shut-downs for coupling repairs have gone forever.



Two spur gears, one on each shaft end, are completely and continuously meshed in oil with the internal gears of a floating sleeve. The shafts and sleeve revolve noiselessly as one unit, allowing free angular and lateral movement.

Purely Mechanical Flexibility

See how simple it is. Mechanical flexibility is used throughout. See the diagram. See the way simple or compound misalignment is taken up by the floating sleeve principle. Instead of relying on flexible materials that would inevitably fail, all misalignment is taken up between the gear faces. Oil, under centrifugal pressure, carries the load.

Today over twenty million horsepower is being transmitted through Fast's couplings, only because coupling users have discovered that Fast's coupling is a permanent piece of transmission machinery, bought once and for all, and not calling for constant replacements and repairs.

For Your Equipment

No matter how complicated your coupling problem is, remember that Fast's couplings are made to meet all conditions, from small pump and blower service up to huge steel mill reversing drives.

At first, Fast's couplings went into new installations only. Now engineers and plant superintendents are finding it profitable to change to Fast's couplings at once, and avoid expensive shut-downs before they occur.

FAST'S
Self-aligning
COUPLING

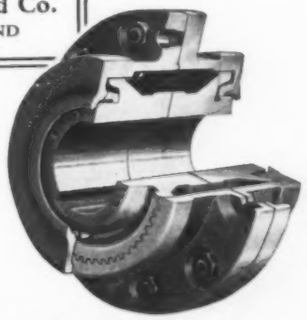
Without flexible bushings, pins, springs, discs, grids or any other flexible materials.

Patented and Manufactured by
The Bartlett Hayward Co.
BALTIMORE, MARYLAND

Send For Free Book

Do not fail to send for the book. It gives all the facts, shows installations, gives the details of construction, shows the standard and special designs, and gives full tables of coupling ratings and dimension data.

The full facts will convince you that Fast's coupling solves the costly coupling problem once and for all.



— — — — SIGN AND MAIL TODAY — — — —

PLEASE SEND ME THE FREE BOOK

THE BARTLETT HAYWARD CO.
200 Scott Street
BALTIMORE, MARYLAND

SIGN HERE

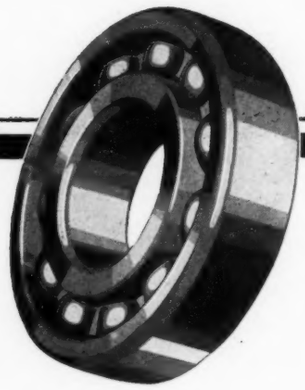
Company _____

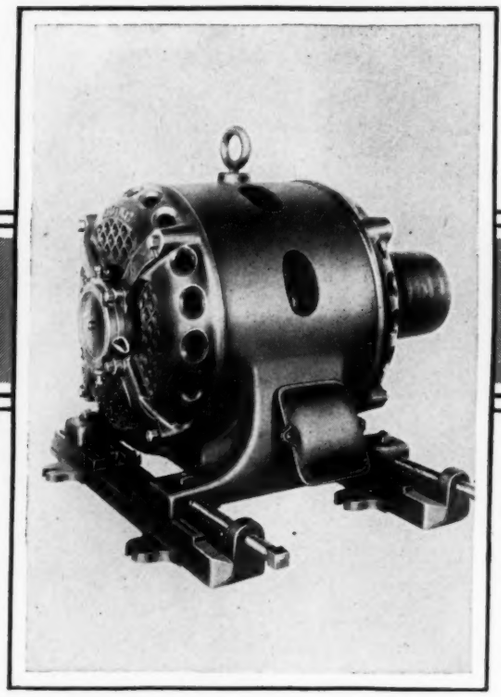
Individual _____

Address _____

City _____

Ball Bearings Are Used In Over Fifty Different Makes of Electric Motors





957

CENTURY ELECTRIC COMPANY is one of more than fifty makers supplying electric motors with ball bearings as standard or optional equipment.

Ball bearings have true rolling motion. They are not subject to the effects of wear.

—successfully carry loads due to high speed, heavy thrust and severe shock without need of readjustment.

—require minimum attention, for they need inspection and relubrication but once a year.

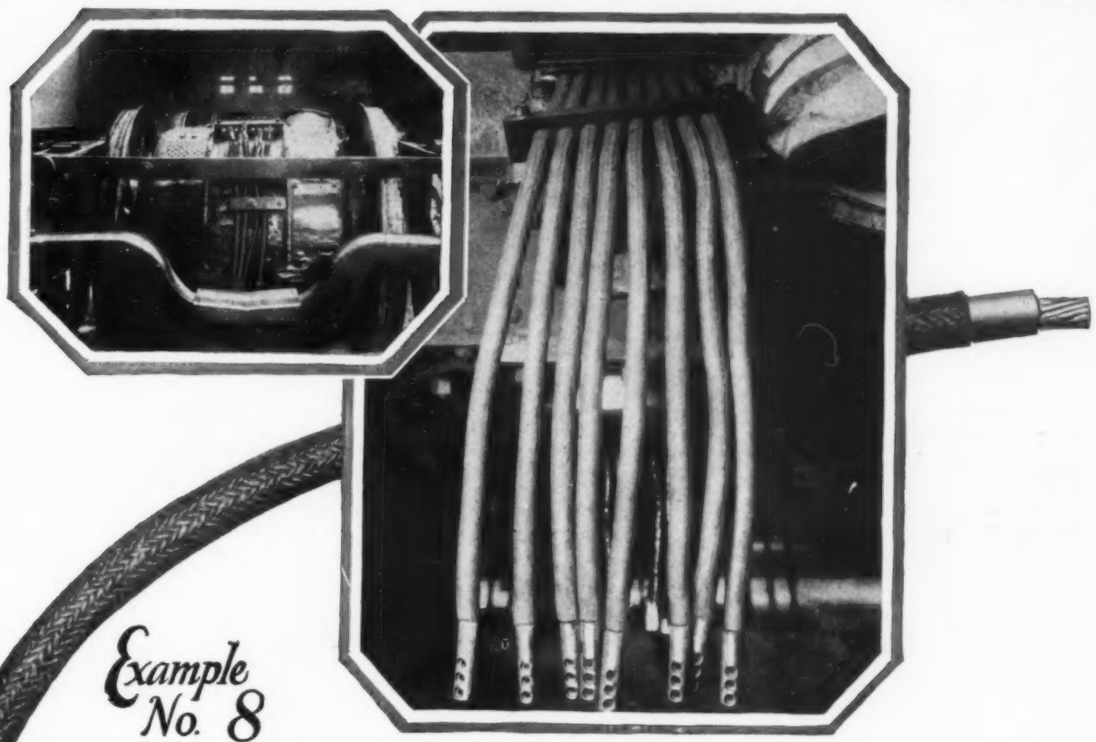
—cannot be equalled for endurance and reliability, as they maintain the original electrical and mechanical efficiency of electric motors throughout a greatly extended period of useful life.

You can build into your motors all these advantages by equipping them with New Departure Ball Bearings.

Write for "Cutting Your Costs" and "Booklet K," explaining in detail the advantages and economies of ball bearings. Sent on request.

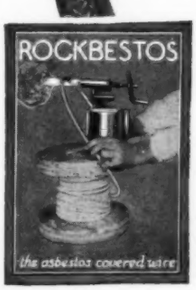
THE NEW DEPARTURE MANUFACTURING COMPANY, Bristol, Connecticut; Chicago, Detroit and San Francisco.

WHY-WHEN and WHERE TO USE **ROCKBESTOS** —*the asbestos covered wire*



Example No. 8

Rockbestos should be used for furnaces, ovens, switchboards, controllers, boiler room lighting circuits, motor leads and internal connections — in fact, wherever wire encounters heat.



Where Protection is Needed Against Arcing and Fire

Here are shown the Rockbestos leads from control equipment to motor of a N. Y., N. H. & H. Railroad electric locomotive.

The insulation on leads in this type of installation is subject to severe conditions. Arcing from loose leads and poor contacts will not affect Rockbestos insulation. It will not communicate fire due to arcing or from other sources.

Other equipment is safe from fire with Rockbestos insulation around. In addition to its perfect insulation, it is impregnated with a flame-proof compound and for casual moisture.

Rockbestos is *permanently* flexible and will not deteriorate with age.

ROCKBESTOS PRODUCTS
C O R P O R A T I O N
NEW HAVEN, CONN.

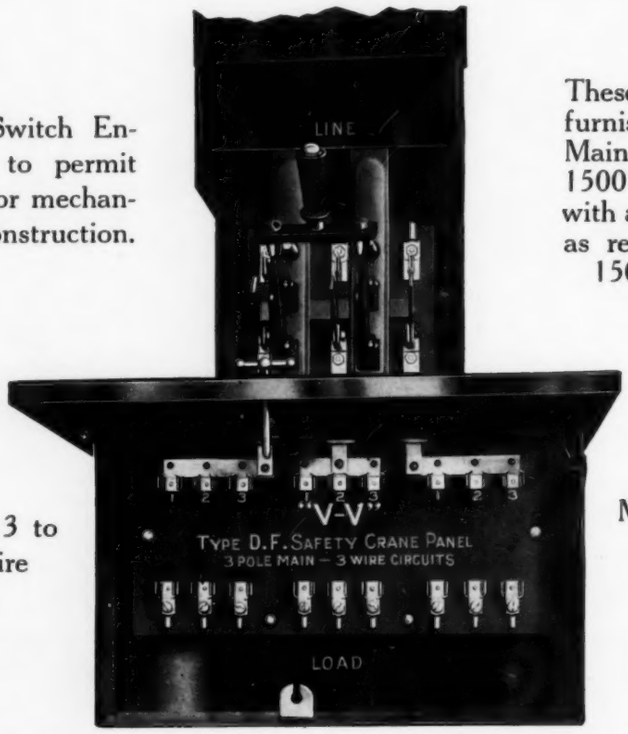
5942 Grand Central Term. Bldg., New York 465 Union Trust Bldg., Pittsburgh, Pa. 224 Madison Term. Bldg., Chicago
On the Pacific Coast—C. Dent Slaughter.

"V.V."

SAFETY SWITCH DEVICES

SAFETY CRANE AND DISTRIBUTION PANEL

Cut shows the Switch Enclosure removed to permit view of the interior mechanism and sturdy construction.



These equipments can be furnished with any size Main Switch from 100 to 1500 ampere capacity, and with as many fusible circuits as required of sizes 30 to 1500 ampere capacity.

Made for 2 to 2, 3 to 2 and 3 to 3 wire installations.

Made for 125-250-500-600 volt N. E. C. S. fuses.

Illustration shows a standard 3 to 3 Wire Fuse Distribution Panel having a 100-Ampere, 3-Pole Main Switch.

This arrangement insures safety to the operator, as the door is interlocked with the main switch, which must be thrown "OFF" before access to the fuses is possible. The fuse door must likewise be closed again before the main switch can be thrown in the "ON" position.

V. V. FITTINGS COMPANY

MAIN OFFICE AND WORKS
PHILADELPHIA, U. S. A.

New York Office: 50 Church Street

Chicago Office and Warehouse: 710 West Jackson Blvd.

Morgan Quality Forging Equipment

—Built by Pioneer Hammer Builders—

DROP HAMMERS
1000 to 16000 Pounds Capacity

FORGING HAMMERS
150 to 40000 Pounds Capacity

FORGING PRESSES

SINGLE FRAME TYPES
150 to 500 Tons Capacity

FOUR COLUMN TYPES
Up to 6000 Tons Capacity

THE MORGAN ENGINEERING COMPANY

ALLIANCE, OHIO, U. S. A.

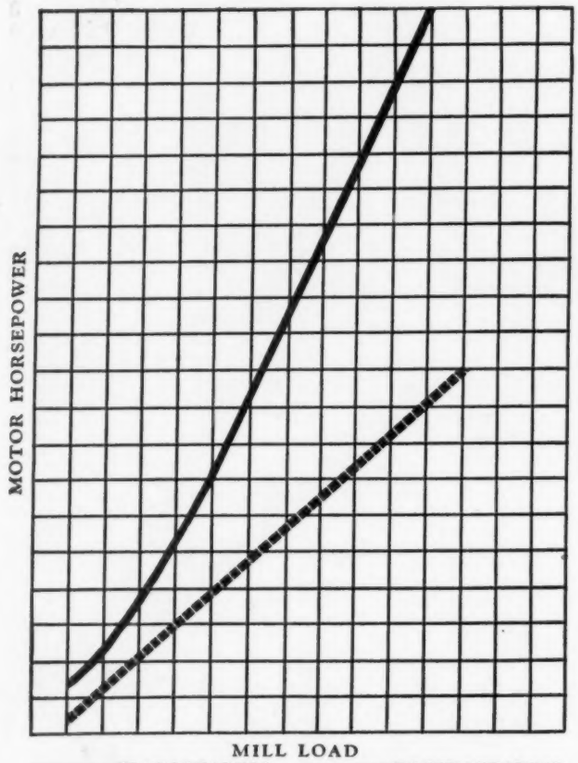
Electric Traveling Cranes, Rolling Mill Machinery, Steam Hammers, Steam Hydraulic Forging Presses

Hydraulic Presses, Rock Crushers, Machine Work of all kinds, Special Machinery for any purpose.

New York: 150 Broadway Pittsburgh: 1420 Oliver Bldg.

Designers, Manufacturers and Contractors

HORSEPOWER!

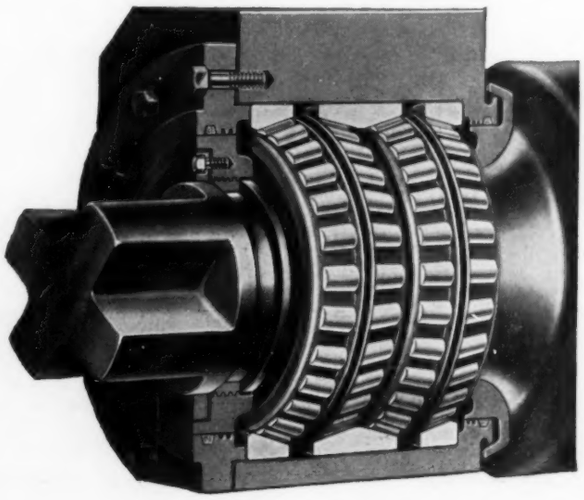


COMPARATIVE MOTOR HORSEPOWERS (ACTUAL RATING) FOR ROLLING MILLS

What Determines Your Motor Ratings?

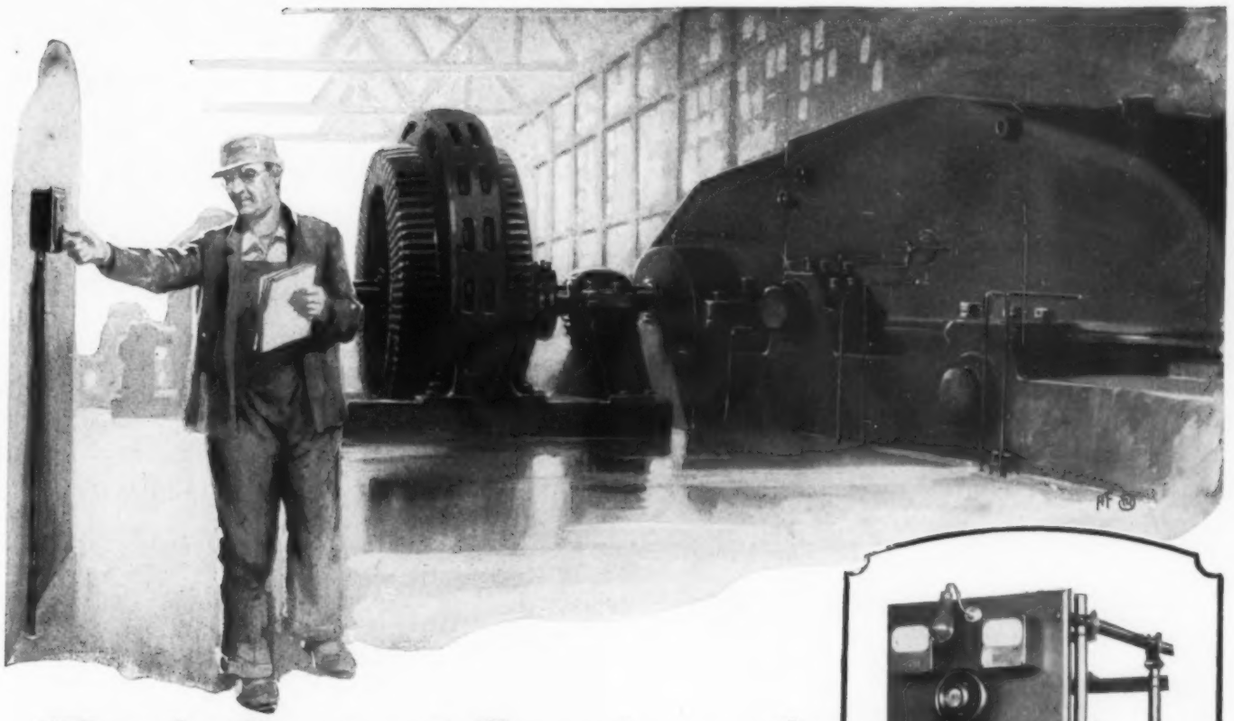
THE large friction component of rolling mill loads has a decided influence in the selection of the motor drive—usually for the worse where operating efficiency is concerned. For a mill of any given rating, motors must be chosen for their ability to meet excessive peak loads, and compensate for the friction component of the rolling load, rather than on a basis of the normal mill rating. As a consequence, mills must be overpowered by a ratio that increases out of all proportion as the mill rating goes up. The disadvantages of such a system are obvious.

With Timken Bearings on the roll necks, the friction component is reduced to a point where motor selection can be made entirely on the basis of the normal mill rating. Instead of overpowered, the mill can be actually underpowered; and the inherent overload capacity of the motor can be depended on to carry any peak loads that may occur. As a result, there is a considerable gain in overall efficiency, both economic and practical. In the first place there is a more than worthwhile reduction in the initial cost of the motor and driving equipment. In addition, power consumption is radically decreased, and power waste eliminated; maintenance and lubrication costs are reduced to a minimum; continuity of service is assured, and production volume increased. And, these advantages are made permanent by the bearing quality resulting from Timken tapered construction, Timken *POSITIVELY ALIGNED ROLLS*, and Timken electric steel.



THE TIMKEN ROLLER BEARING CO., CANTON, OHIO

TIMKEN
Tapered
ROLLER BEARINGS



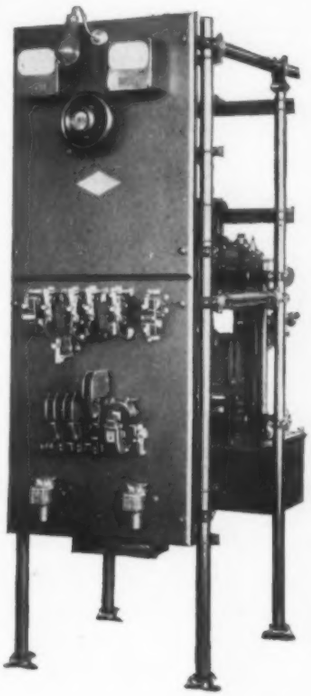
"Push-Button" Starting of the Synchronous Motor

—with synchronization controlled the correct way—by motor speed

SINCE the *time of acceleration* may vary due to either line voltage or load, the *correct* method of automatic synchronization is that which is related to *motor speed only.*

The E-M Frequency Relay, working independently of either time or load, applies the excitation exactly at a predetermined motor speed *every time.* This frequency relay is to be had only in the E-M Automatic Starter. Further advantages are its use to control the switching operations in reduced voltage starting and to provide an automatic "kick-off" when voltage dips occur. If the motor has been designed with pull-in torque to re-synchronize against load, or the load is automatically reduced, acceleration and re-synchronization occur and there is no break in production.

E-M Starters and E-M Motors are fully described in the new manuel "The Most Efficient Drive in Industry" —gladly sent on request.



E-M reduced voltage starter of the oil-switch type. The switching from reduced to full voltage is handled automatically by the E-M Frequency Relay at the correct motor speed, as is the application of excitation for synchronizing. The motor is synchronized in the shortest possible time and with a minimum of current inrush.

Electric Machinery Mfg. Company

Specialists in Apparatus for Power Factor Improvement

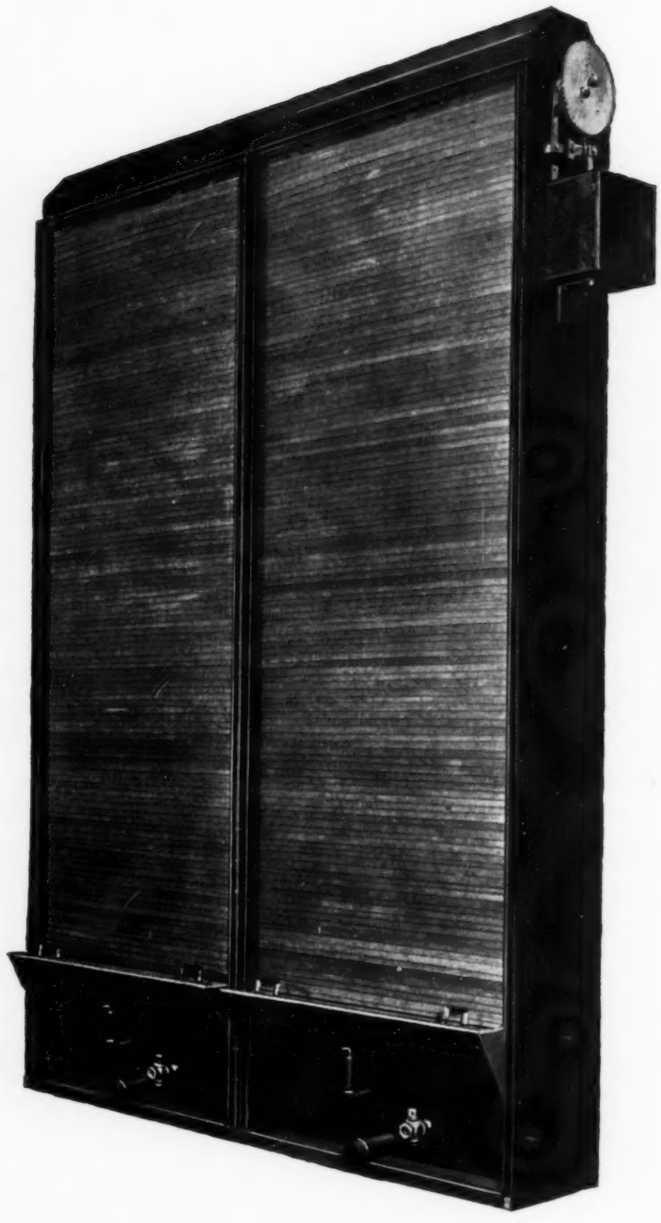
1337 Tyler Street, N. E. Minneapolis, Minnesota

EM *Synchronous* MOTORS

THE DEPENDABLE ECONOMICAL DRIVE OF PROVEN PERFORMANCE

(4051)

LESS *than* 1/100 of an inch Variation *in Resistance!*



DURING the entire 500 hours of a recent non-stop, 21-day test, a Reed Multi-Panel (Continuous Automatic) Air Filter, in steel mill service and operating under most adverse dust conditions, *showed less than 1/100 of an inch variation in resistance to air flow!* Tests of air-cleaning performance, made at the same time, proved that this new filter appreciably exceeded its guaranteed efficiency of 98%—*more nearly approached perfect air cleaning than has ever before been attained.* It will pay you to know the engineering reasons for the success of this remarkable new filter. Use the coupon for convenience.

REED AIR FILTER CO., *Incorporated*
230 Central Avenue · LOUISVILLE, KY.
Representatives in Principal Cities.

Reed Air
TRADE MARK
filters ALL METAL

Use This

REED AIR FILTER CO., *Incorporated*
230 Central Avenue, Louisville, Ky.

Send, without obligating me, full details about the recent three-week, non-stop test and full engineering facts about the Reed Multi-Panel (Continuous Automatic) Air Filter.

Name ..... *City* .....

Company ..... *State* .....

The Condit Type E-20 Oil Circuit Breaker is fully in step with modern, high speed production efficiency. It meets the many demands throughout industry for 400 ampere, 2500 volt motor control service.

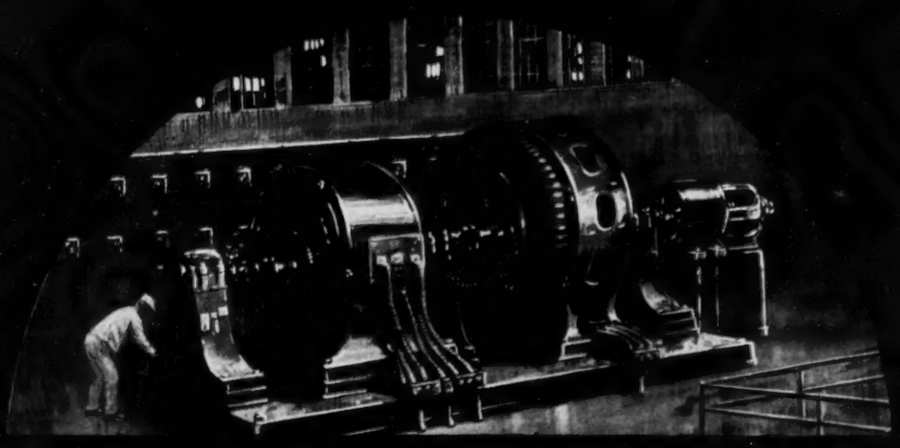
Advantages include thermally operated overload time lag unit —a tremendous aid to production efficiency—trip-free automatic mechanism, exceptionally heavy panel steel frame and vibration-proof latch.

May we send Bulletin 472-3.

CONDIT ELECTRICAL MFG. CORPORATION
Manufacturers of Electrical Protective Devices
BOSTON, MASS.
Northern Electric Company
LIMITED
Distributor for the Dominion of Canada

SPECIFICATIONS: ***Standard capacity up to 400 amperes at 2500 volts, wall mounting, manually operated, non-automatic and automatic.***

CONDIT



ECONOMY *renewable* FUSES

INDUSTRIES using electrical energy save 80% annually in fuse maintenance costs when they install Economy renewable Fuses in the place of "one-time" fuse-equipment.

Economy Fuse performance is a matter of record—they were the first fuses using inexpensive bare renewal links for restoring blown fuses to their original efficiency to be *Approved in All Capacities* by the Underwriters' Laboratories.

Economy "Drop-Out" Renewal Links cost but little and make the restoration of a blown fuse the work of a moment only.

Your plant needs Economy Fuses. Investigate the quality of the electrical protection you now have from the standpoint of dependability, efficiency and economy.

Then order Economy Fuses installed.

For Sale by all leading Electrical Jobbers and Dealers.

ECONOMY FUSE & MFG. CO., Chicago, U. S. A.

Economy Fuses are also made in Canada at Montreal

This company also manufactures a complete line of

TAPERED ROLLER BEARINGS

using High Carbon Chrome Steel in cups, cones and rollers, in combination with a cage or roll-retainer of Anti-Friction Metal. This cage has slots molded to the exact taper and contour of the roller, assuring positive and permanent alignment of the rollers. Also adding strength to the assembly as well as reducing friction to a minimum.

Avoid costly Shut-downs

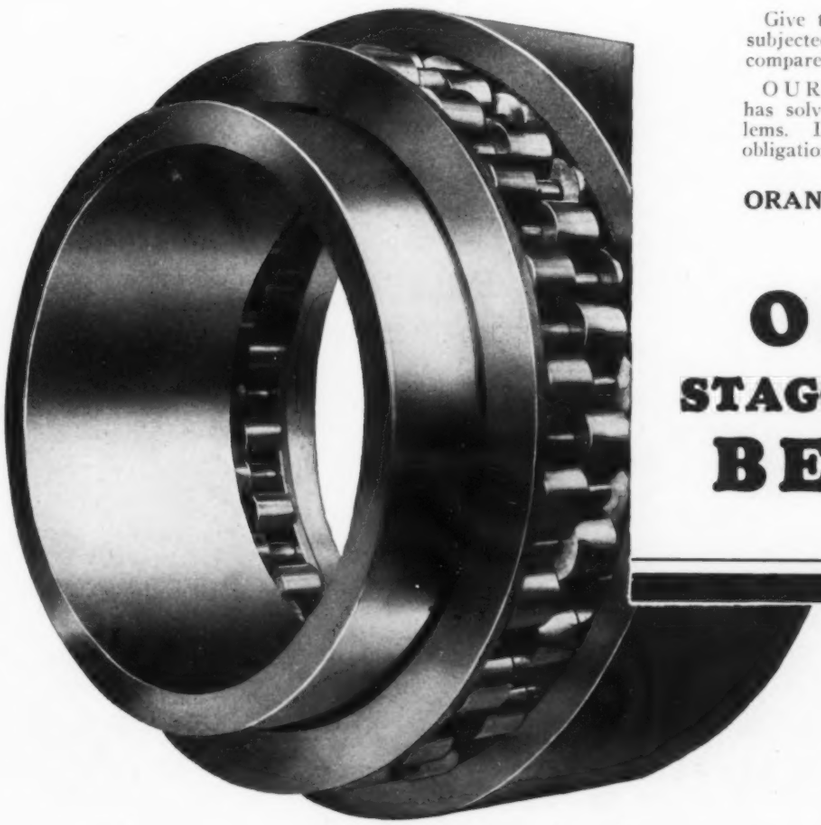
PUT an end to the costly delays resulting from bearing troubles, by equipping your machines with Orange Staggered Roller Bearings.

Stresses that cause ordinary bearings of the long-roller type to warp and break are carried indefinitely by the ***short rolls*** of these scientifically designed bearings. The heaviest loads are ***distributed evenly*** over the ***entire bearing surface.*** No warping—no conical wear—no tracking—no destructive tendency to work out of alignment.

Back of Orange Staggered Roller Bearings is the reputation of an old established firm of ***Bearing Specialists***—plus a record of hundreds of successful installations over a period of 18 years.

The finest grade of high carbon, high chrome electric furnace tool steel goes into Orange Staggered Roller Bearings, giving them maximum toughness for resisting wear.

Built to the highest standards of precision, double checked for possible error before release from the testing table.

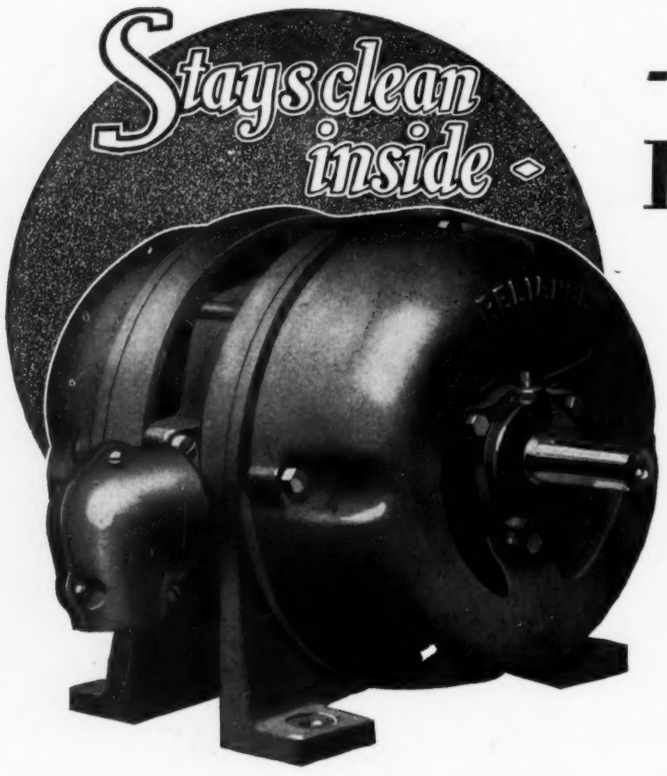


Give them a trial on the machines that are subjected to the heaviest bearing stresses, and compare the results.

OUR ENGINEERING DEPARTMENT has solved hundreds of difficult bearing problems. Let us help you to solve yours. No obligation for consultation.

ORANGE ROLLER BEARING CO.
Orange, N. J.

ORANGE
STAGGERED ROLLER
BEARINGS



Fully-enclosed Fan-cooled Reliance Induction Motor

This is a fully-enclosed motor cooled by air blown across the outside of the stator and copper radiating bonnets which seal the inside against dirt. With this construction it is possible in most cases to get the same ratings as from an open motor of the same frame size.

- - *and* Lasts Longer *in* Steel Mills

This enclosed fan-cooled induction motor will last longer on many steel-mill applications because the windings are sealed against dirt. Air gaps cannot become clogged. You get this protection at reasonable cost and without excessive increase in size or weight.

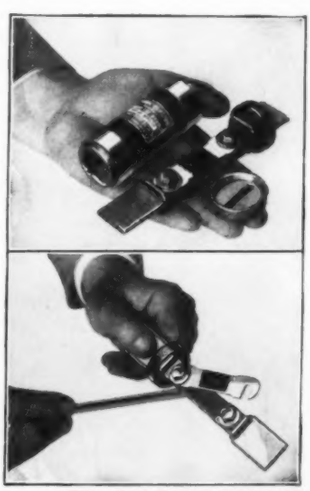
Don't think of this motor simply for very bad conditions. There are many places where open motors may now be giving fairly satisfactory results that savings in inspection, cleaning and repairs would more than justify the use of this new motor.

Bulletin 103 tells in detail why this motor cuts maintenance costs.

RELIANCE ELECTRIC & ENGINEERING CO.
1080 Ivanhoe Rd., Cleveland, O.
Branches: Birmingham Boston Buffalo Chicago Cincinnati Detroit New York Philadelphia Pittsburgh St. Louis

RELIANCE A-C D-C MOTORS
With Ball Bearings

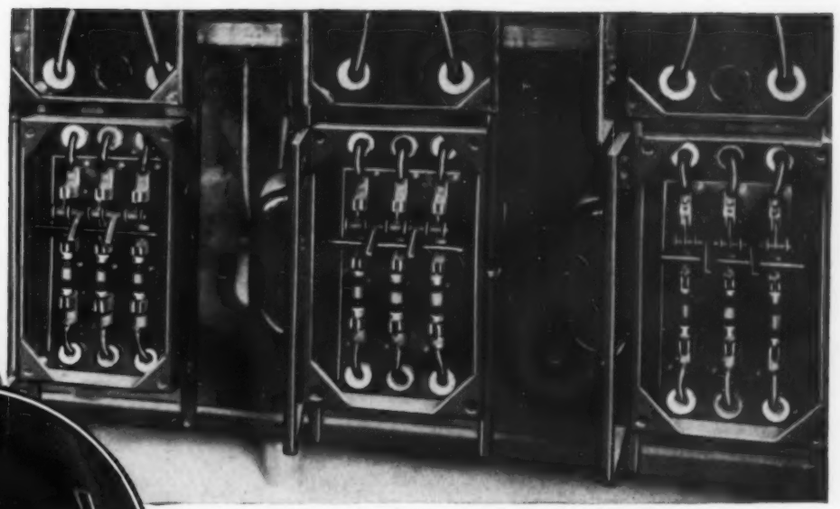
Venting, an important consideration in fuse operation, is secured and maintained by means of carefully proportioned passages in the case. This method provides for the escape of gasses and prevents molten metal from "freezing" the caps.



Fewer number of parts promote speed in renewals. Only one cap is removed. The other remains on the knife blade.

Fusible link of knife-blade type is notched at both ends to permit slipping into or out of place, when studs are only slightly loosened.

The UNION-GEM-JEFFERSON Line
is Sold Through Wholesalers



Meeting the Demand for Low-Cost PROTECTION

NEVER before has value played such an important part in the selection of equipment. For example, more and more plants have learned that fuses are not all alike—that Union Renewable Fuses not only give dependable protection to electrical circuits—but stay in service longer—cost *less* because they are *worth more.*

Simplified design and construction keep Union Renewable Fuses as serviceable as new—after repeated blowouts. The extra heavy and tough grey horn fibre case is vented by an exclusive method. Vents are in the fibre shell and are scientifically proportioned to relieve the pressure generated when the fusible element blows. Molten metal is not forced into end cap threads.

In addition to these advantages, which insure a new fuse for the price of a link, the extreme simplicity of design and fewer parts make renewals quick and easy.

In the knife-blade type, both ends of the fusible link are notched—therefore the studs that hold the link need be loosened only slightly when making renewal. In the ferrule type, two nibs on the washers fit into corresponding holes in the body and prevent the link from twisting. Links are bent at one end to make renewal easy.

Our new catalog No. 33 gives complete facts. Send for your copy—also free FUSE CHART which tells at a glance proper size and style of fuses for dependable electrical protection at low cost.

Chicago-Jefferson Fuse & Electric Co.
1517 WEST 15th STREET
Chicago, Ill.

UNION FUSES

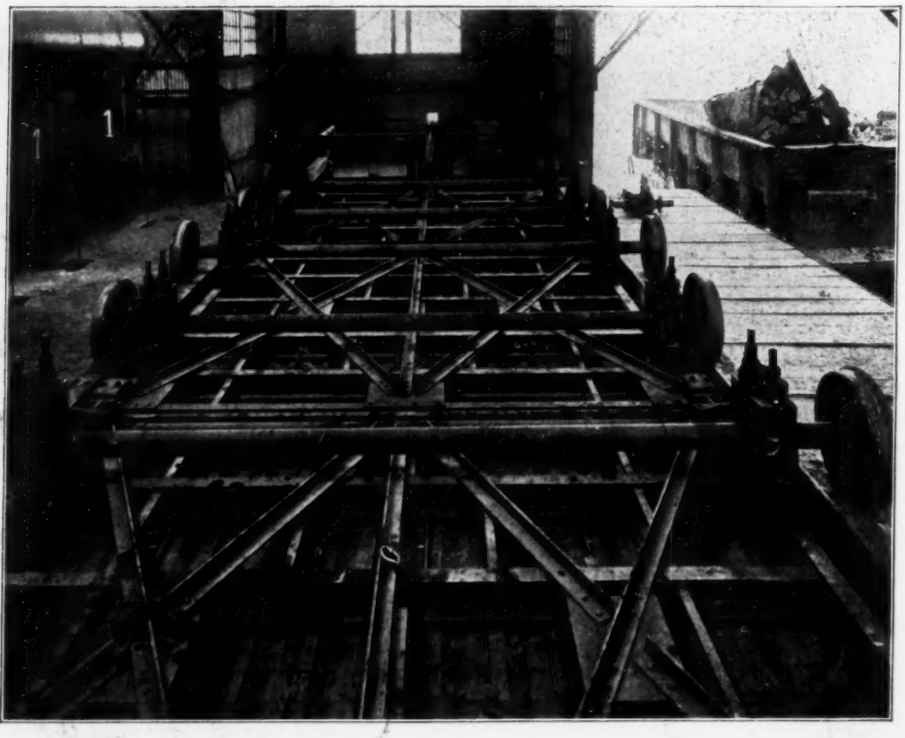
Because they are worth more they really cost less

(8070)

ELIMINATE

Soaking Pit Cover

FAILURE!



Failure of a Soaking Pit Cover or even a portion of it often means more than just the expense of repairing the cover itself. It means a delay in your processes while the pit is cooled and cleaned to remove obstructions which prevent ingots from standing in an upright position.

Detrick Suspended Soaking Pit Covers eliminate the possibility of the failure of the entire cover and also permit the repair of any section without disturbing or endangering the rest of the cover.

Details of construction of Detrick Suspended Soaking Pit Covers are given in our new sixty-four page booklet. Send today for your copy.

DETRICK ARCHES & WALLS

M. H. DETRICK CO., 140 S. Dearborn St., Chicago, Ill.

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Pittsburgh: Empire Bldg.
Cleveland: Penton Bldg.
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